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## The AIRS Forward Model: Validation & In-Orbit RTA

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## Overview

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- Validation data: ECMWF, PREPQC, ARM-CART
- AIRS observations: July 20, Aug 31, Sept. 1,2,5,6,9,10,11
- Aug/Sept. data validation done with the *new* AIRS-RTA at the post-defrost frequencies
- Changes to AIRS-RTA from pre-launch version include: (1) correct frequencies, (2) fringes, (3) new water continuum, and (4) improved CO<sub>2</sub> at 4.3 microns
- Plan to deliver new AIRS-RTA after final testing next week. Includes 2 new predictors for the water continuum, needed because we added temperature dependence to the foreign continuum.
- This new AIRS-RTA contains no direct corrections from AIRS validation.
- Will cover clear FOV selection, bias observations, differences between AIRS-RTA and those based on GENLN2, and some very initial observations of non-LTE and cirrus.

## Clear Selection: 1st find uniform golfballs

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Our FOV selection was based on three semi-independent tests: (1) the uniformity of the FOV radiances compared to all adjacent FOVs, (2) window channels at different wavelengths must have the same  $B(T)$ , after correction for water, and (3) remove outliers by forcing agreement between observed and computed SST to  $\pm 4K$ .

Uniform  $B(T)$  test:

- test channels = [ 759, 903, 2328, 2333 ] = [900, 961, 2611, 2616  $\text{cm}^{-1}$  ]
- calculate  $BT_{mean}$  of test channels for every FOV
- calculate  $|\Delta BT|$  for all 8 adjacent FOVs
- FOV is uniform only if  $\max |\Delta BT| < \Delta BT_{max}$
- $\Delta BT_{max} = 0.25$  Kelvin

## Clear Test

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The clear test compares estimated surface temperatures for some subset of channels. Observed window channel radiances are converted to surface temperatures by adjusting them for the estimated atmospheric effects using the ECMWF model profile.

The test channels are distributed into bins to allow channel (ie bin) averaging prior to comparing the temperatures. The bin temperature comparisons can either between two bins or between a bin and the model surface temperature.

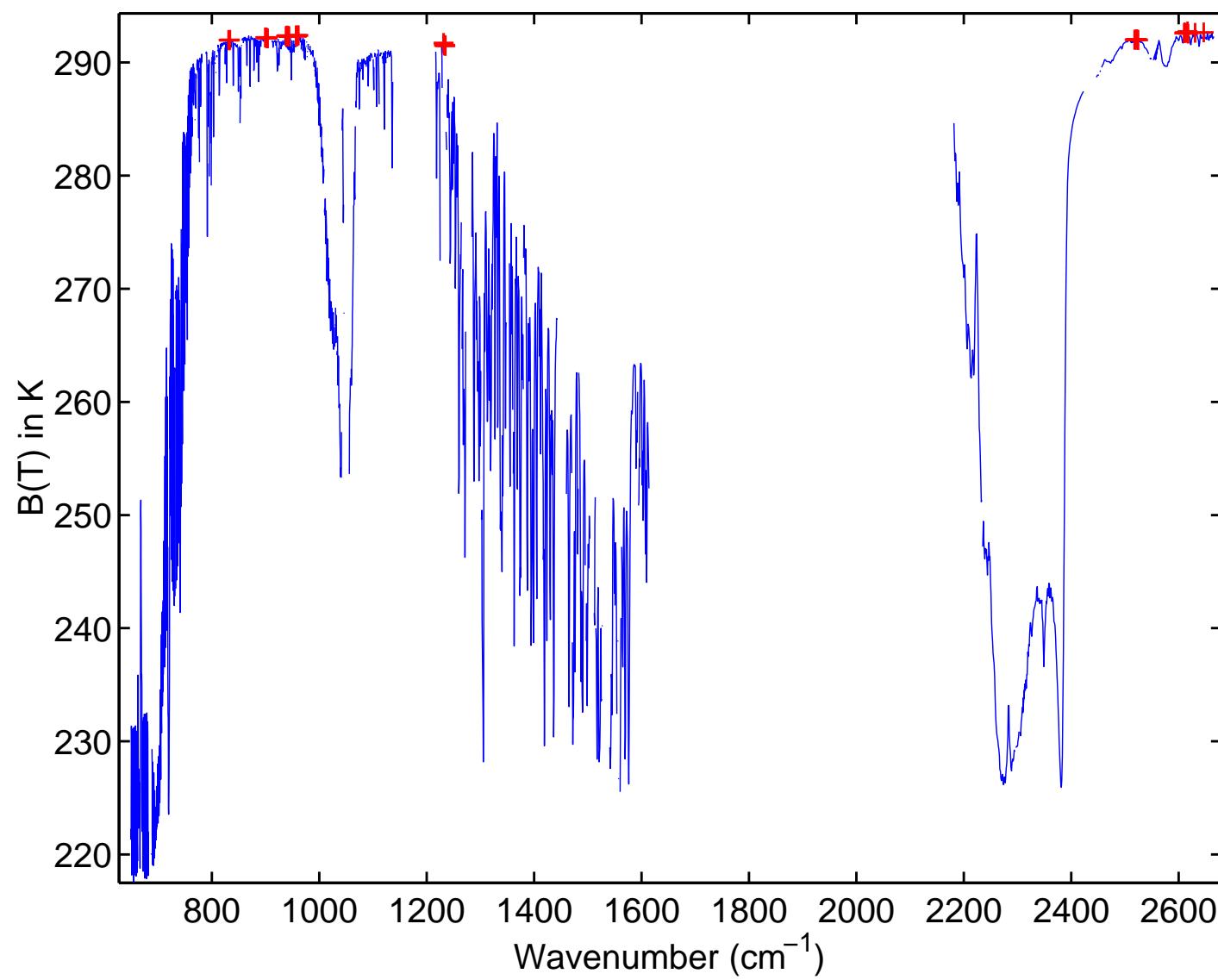
## Clear Test Procedures

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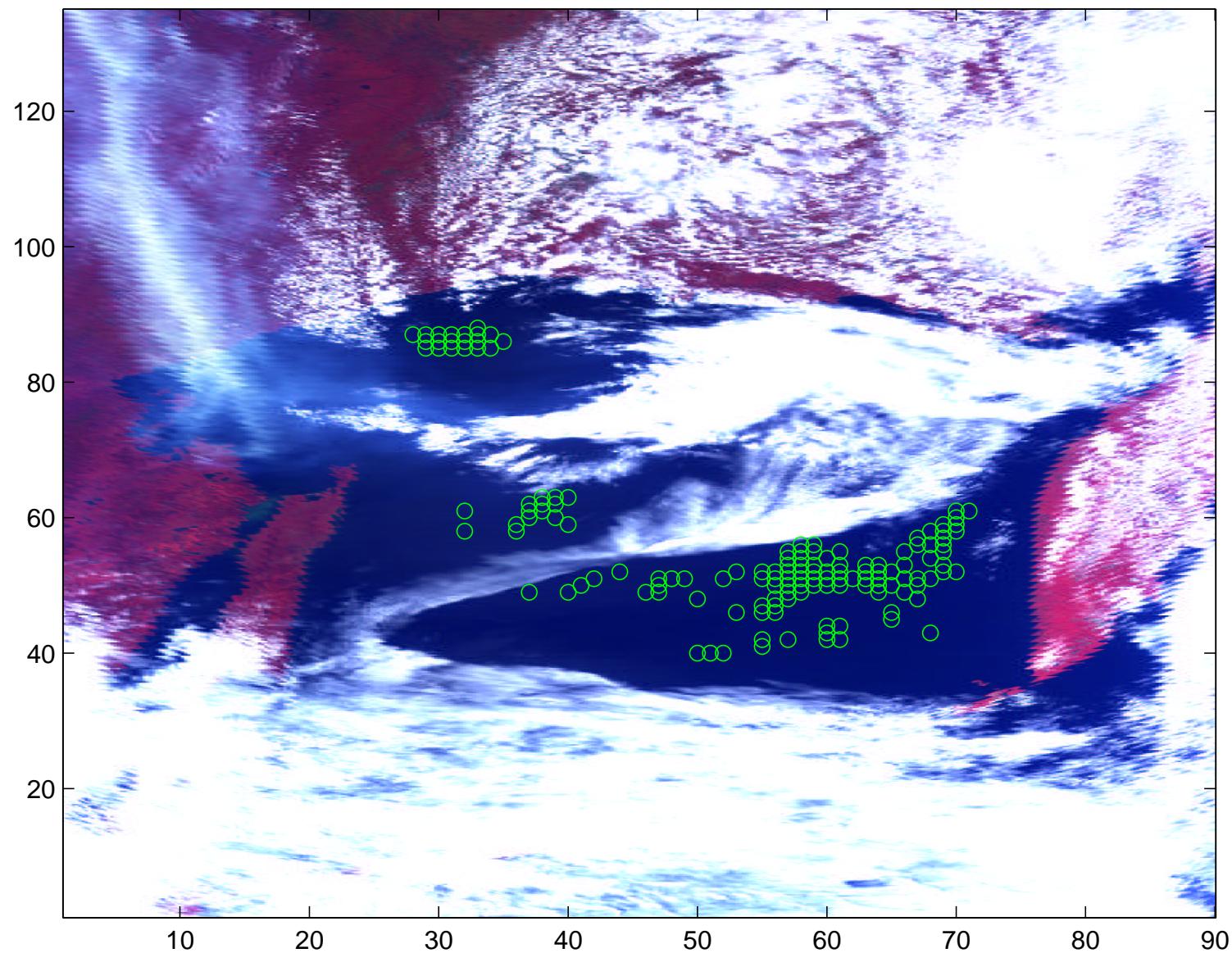
- use the nearest ECMWF profile and sea surface emissivity
- derive an effective sea surface temperature for the test channels by subtracting out the atmospheric effects. This also requires a sea surface emissivity model.
- skip if  $T_{eff} < 273$  K since it is ice not open sea
- sort individual channel surface temperatures into averaging bins
- ignore shortwave test channels if daytime
- compute bin average surface temperature
- compare temperatures between bins
- if delta BT is larger than max allowed difference, profile fails
  - $\Delta BT < 4$  Kelvin for comparisons with ECMWF model  $T_{sea}$
  - $\Delta BT < 0.4$  Kelvin for comparisons between bins
- max land fraction = 0.001

	bin	id1	id2	id3	id4	id5	id6	id7
Channel Bins	1	555	559	562				
	2	757	758	760	764	766	769	
	3	843	847	848	853	857	858	
	4	892	893	896	897	902	903	
	5	1291	1292	1293	1297	1298		
	6	2213	2214	2215	2216	2217	2218	2219
	7	2327	2328	2331	2334	2346	2361	
	8	2388						
	bin1	bin2	$\Delta T$					
Bin comparisons	1	2	0.4					
	2	3	0.4					
	3	4	0.4					
	4	5	0.4					
	4	0	4					
	4	7	0.4					
	6	7	0.4					
	8	0	4					

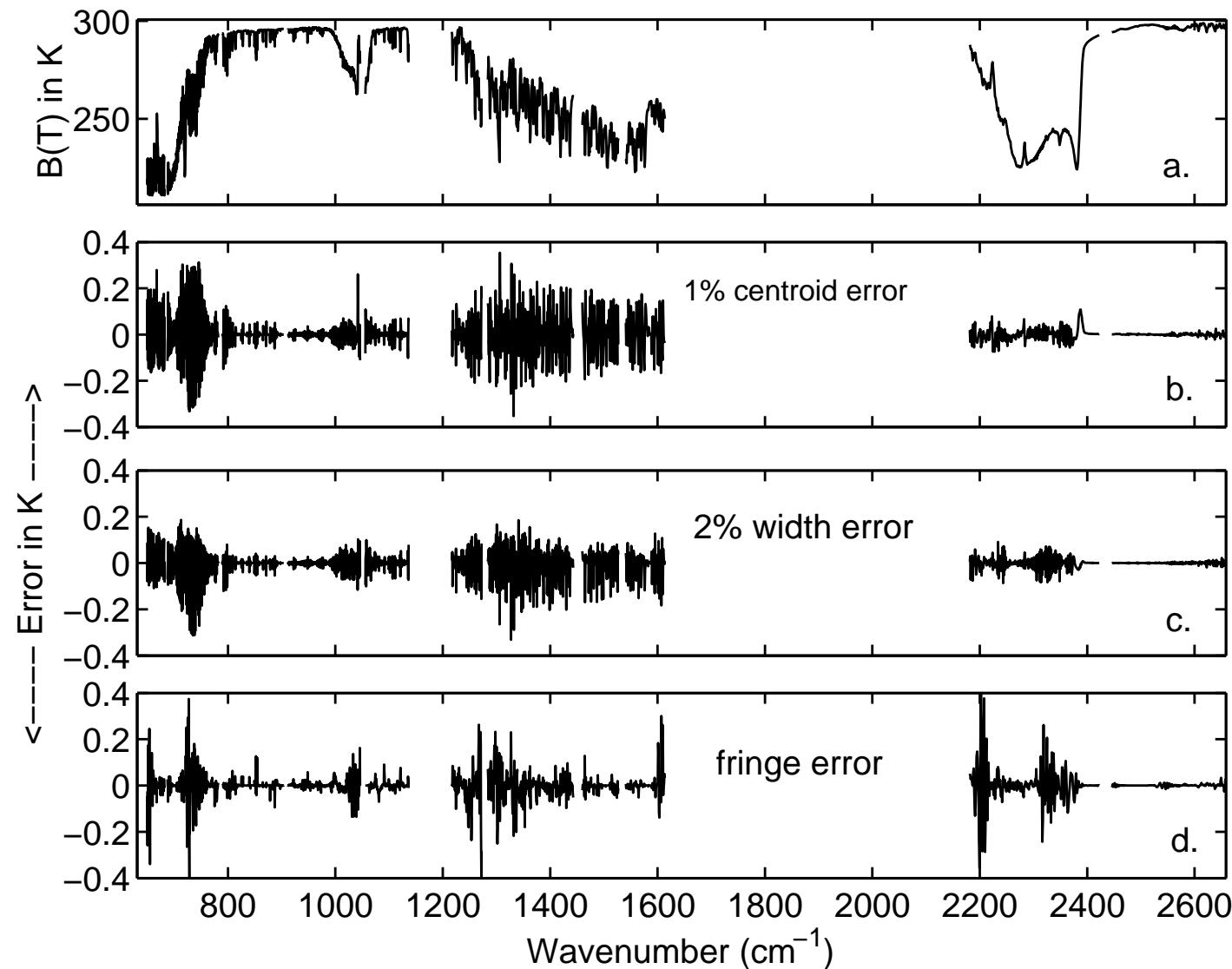
## Clear Test Channels



2002.07.20 AIRS Visible False Colour Granule029



## Forward Model Sensitivity to SRF Parameters

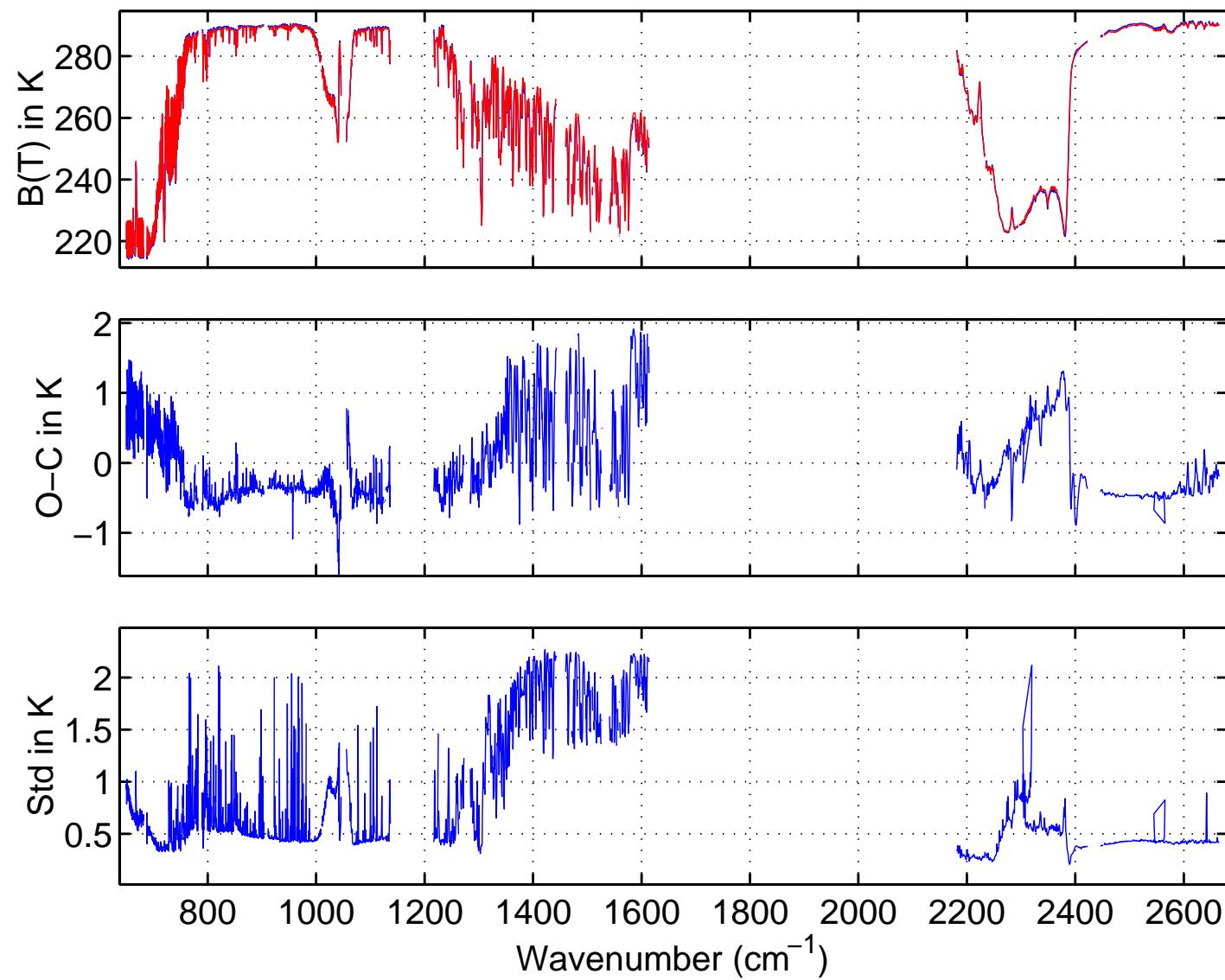


## Bias Calculations

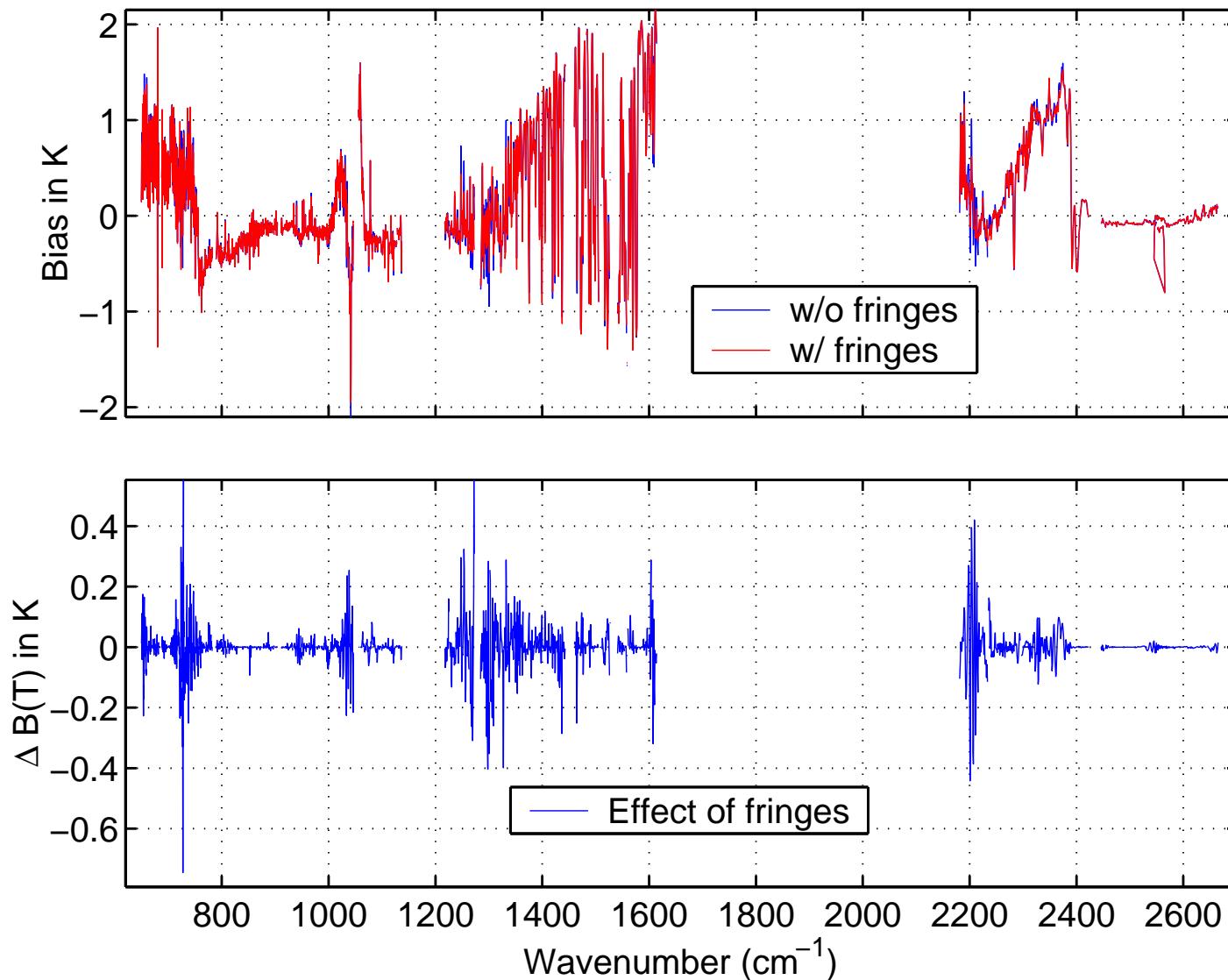
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- ECMWF used for global bias calculations.
- Bias calculations only over water, generally night only
- Restrict latitude to  $\pm 60$  degrees
- All scan angles included, generally nadir is 2-3X more likely to be clear than 45 degrees
- Raob and ARM-CART site results *extremely preliminary*

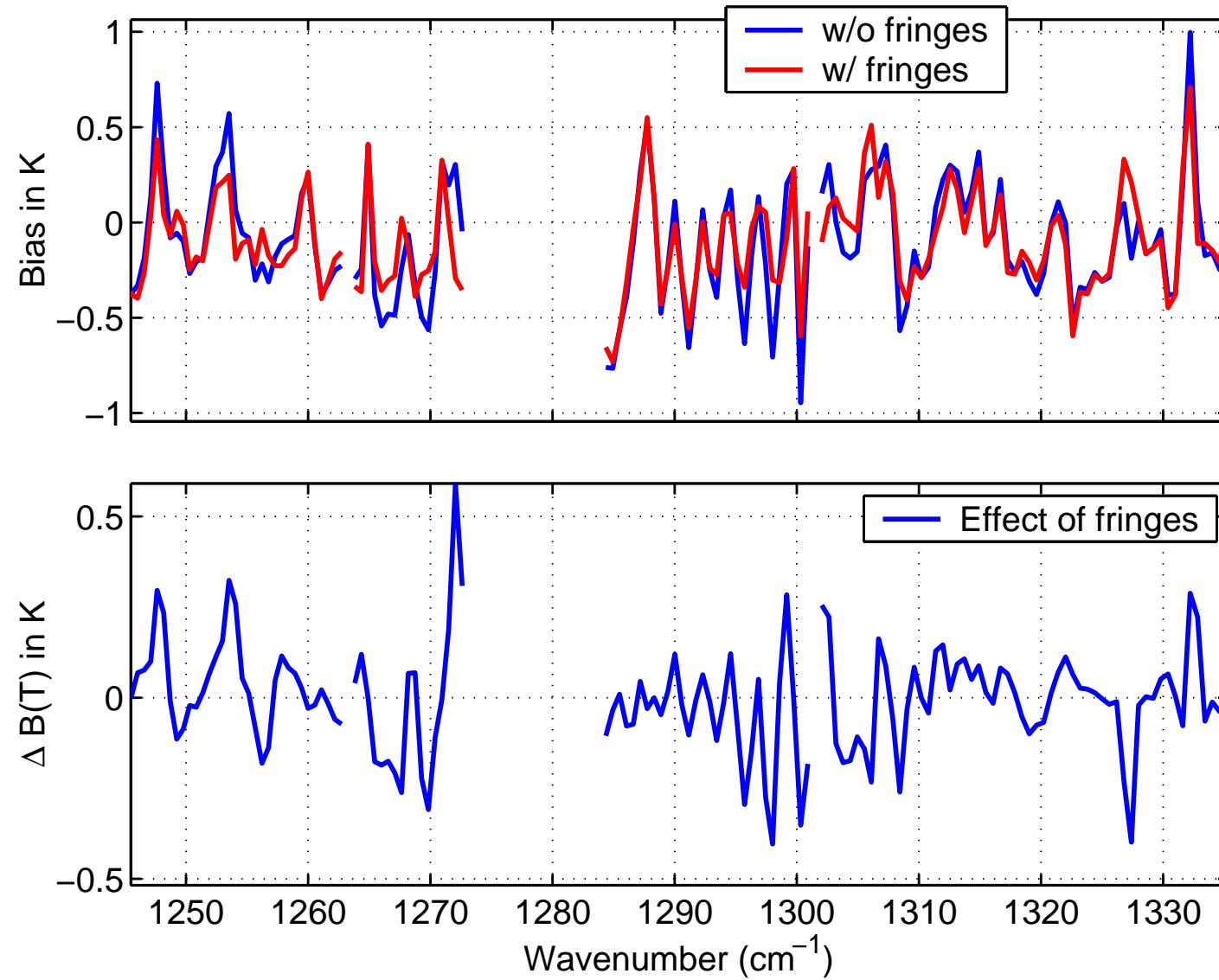
Sept. 10 Bias and Std



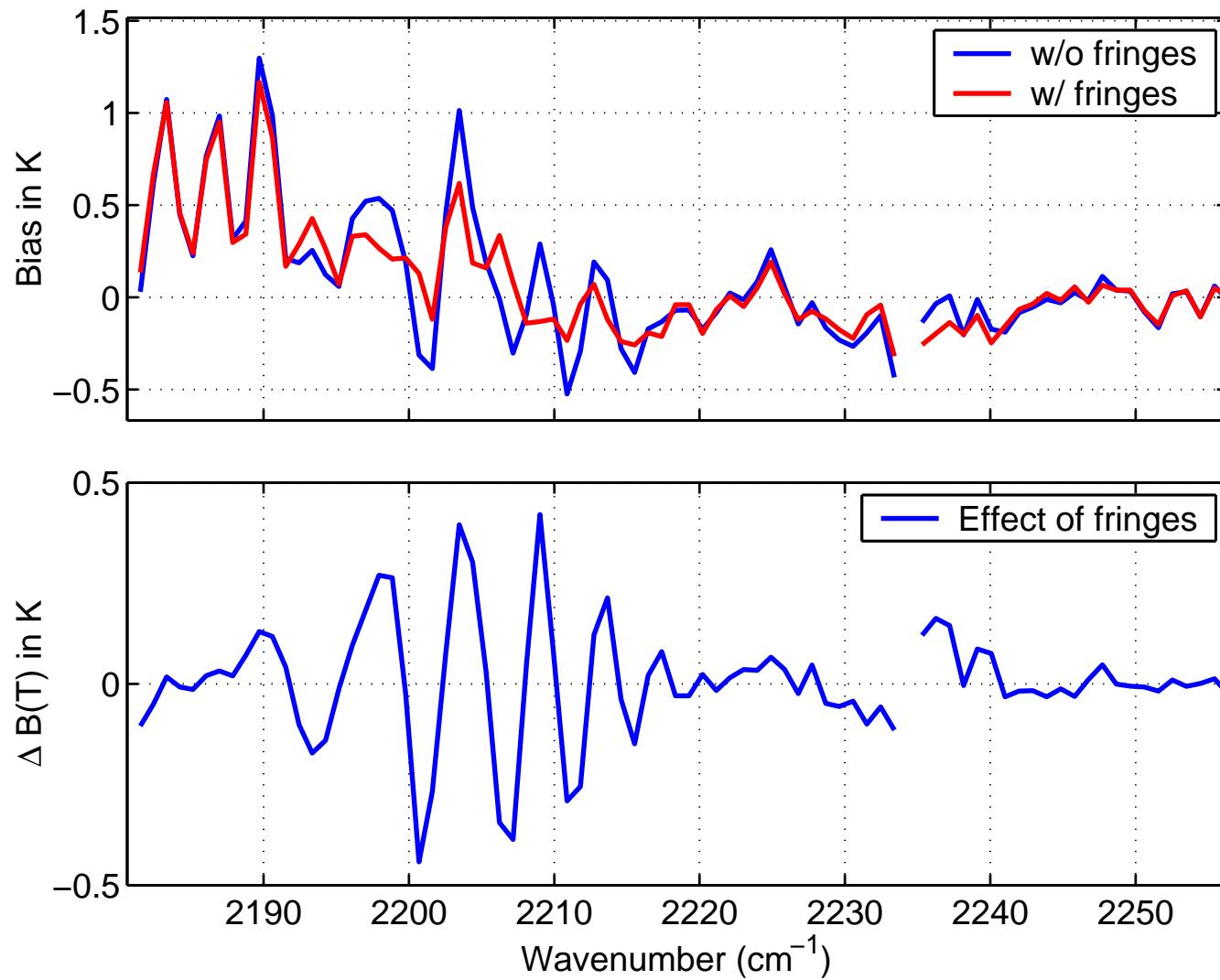
## Fringe Effects, Aug 18, Post-Defrost



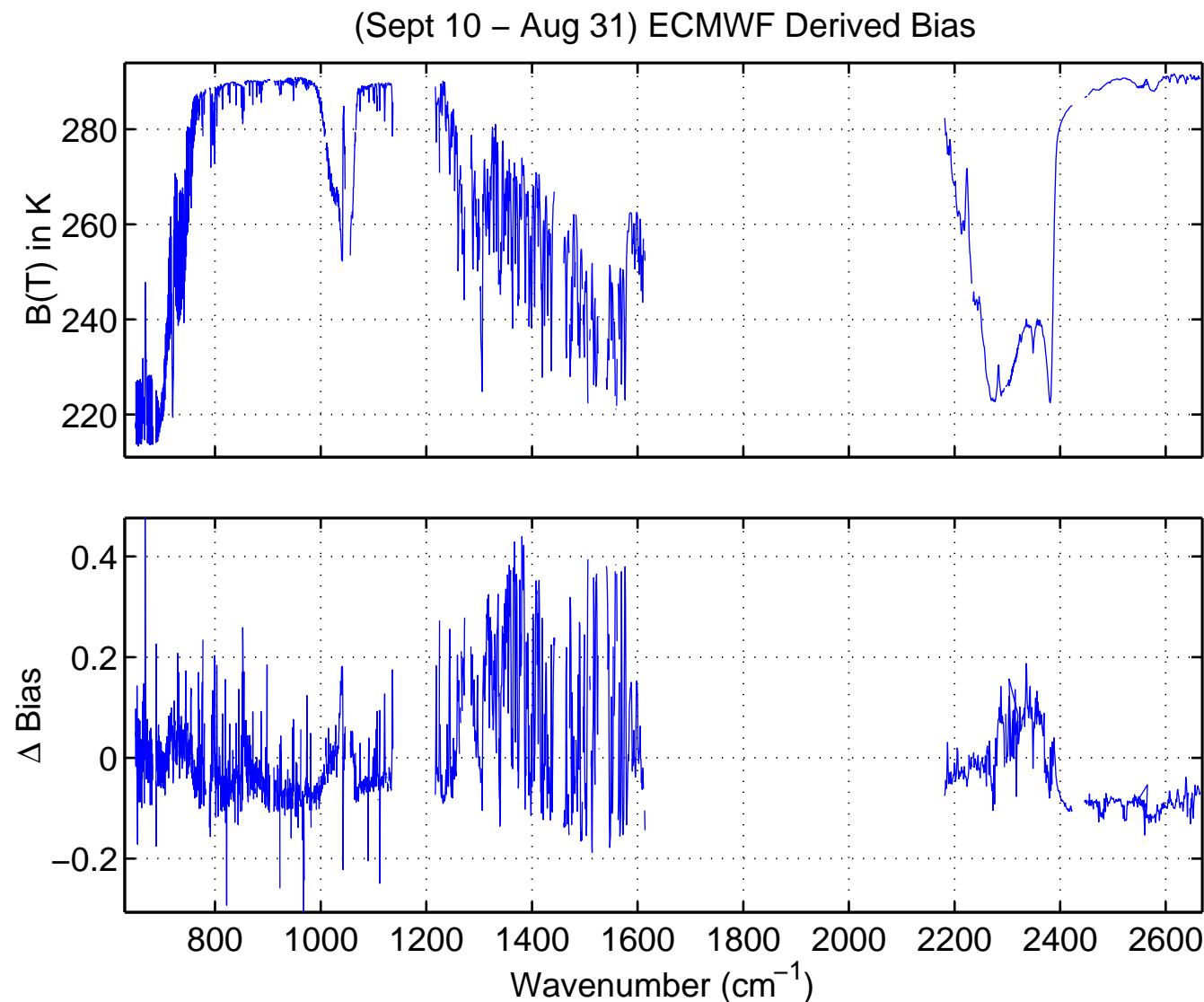
## Fringe Effects, Aug 18, Post-Defrost, Zoom



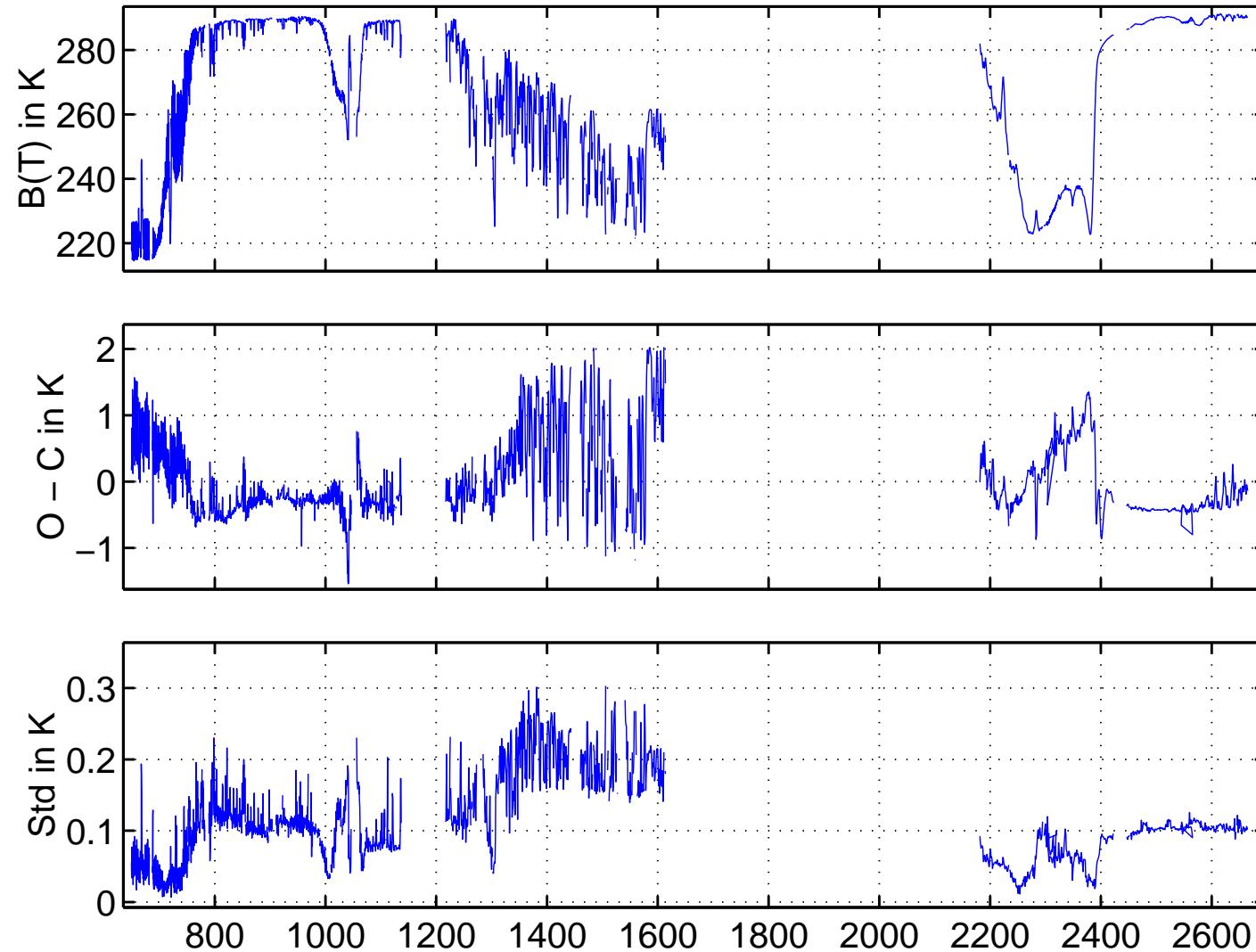
## Fringe Effects, Aug 18, Post-Defrost, Zoom



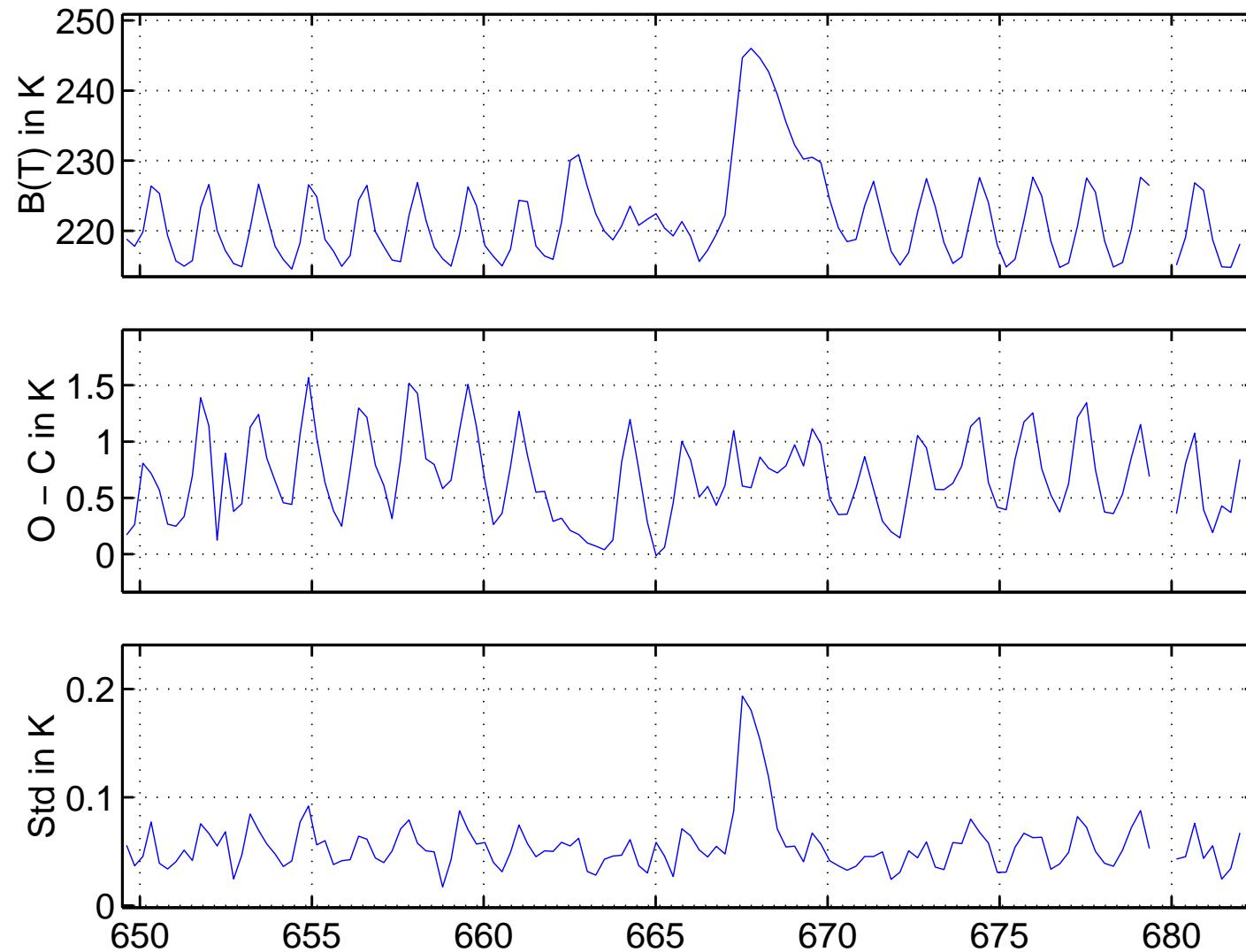
## Bias Stability: Sept 10 vs Aug 31 Global Bias



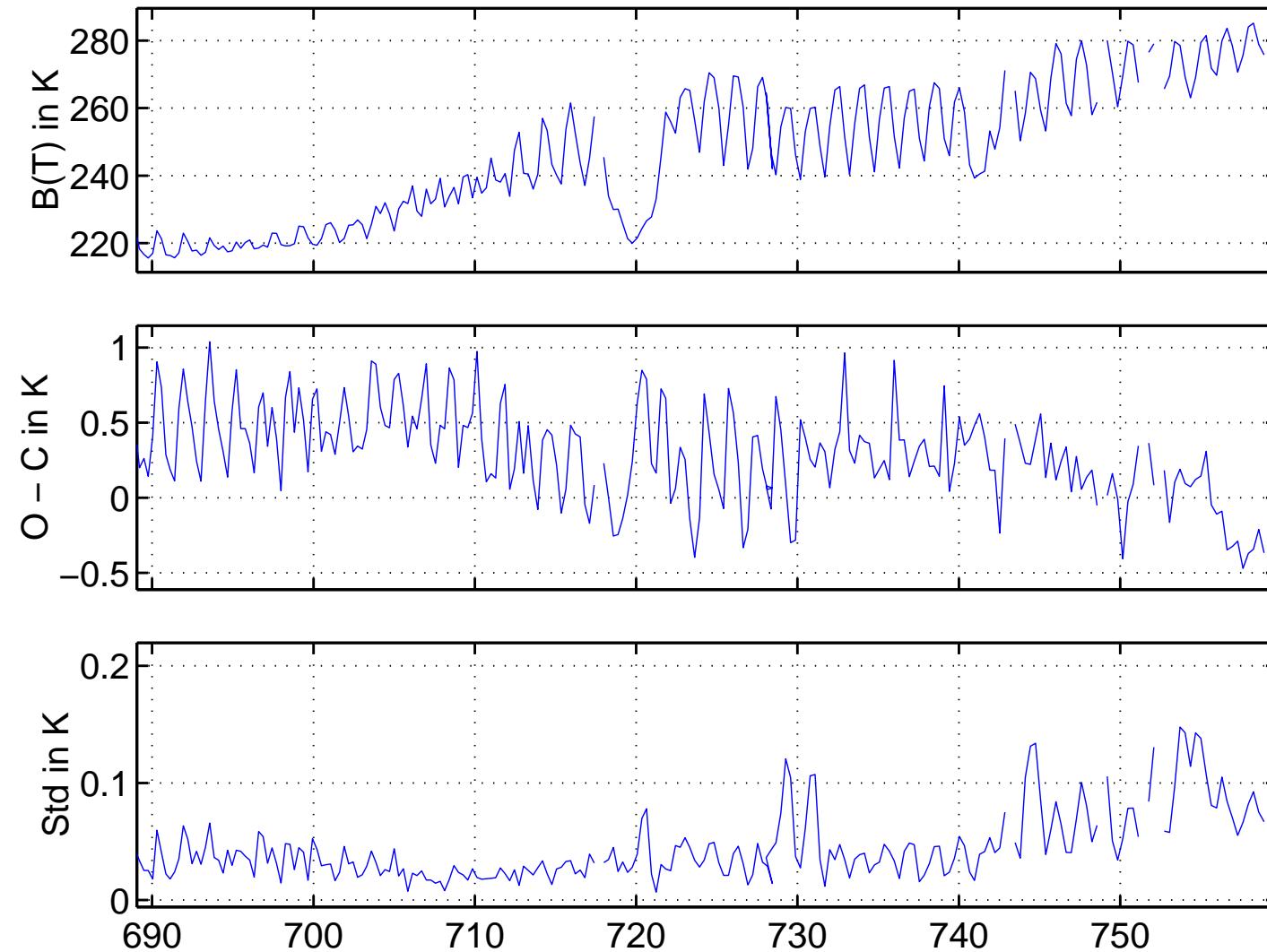
## Mean and Std of Daily Global Bias over 7 days in Sept.



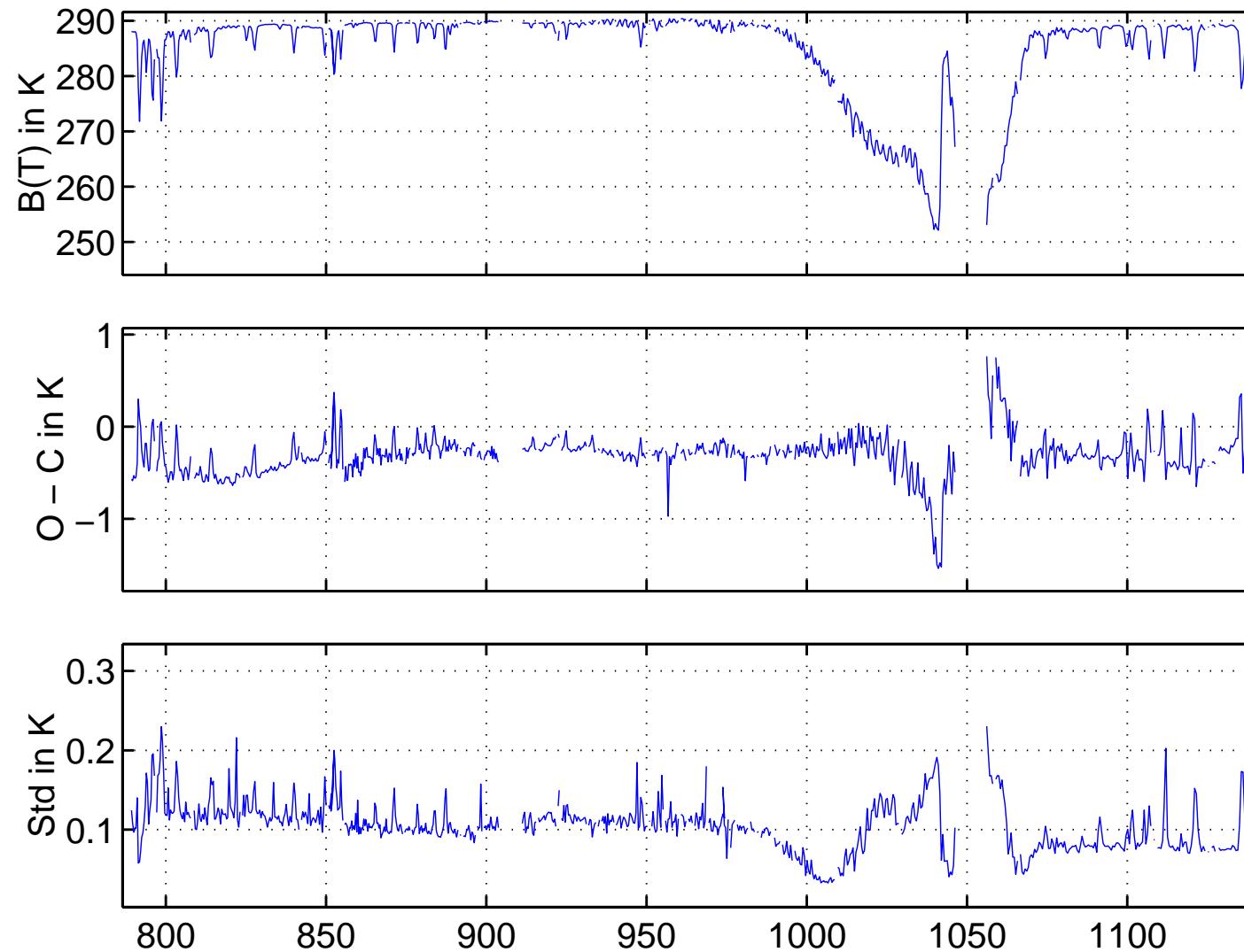
## Mean and Std of Daily Global Bias over 7 days in Sept.



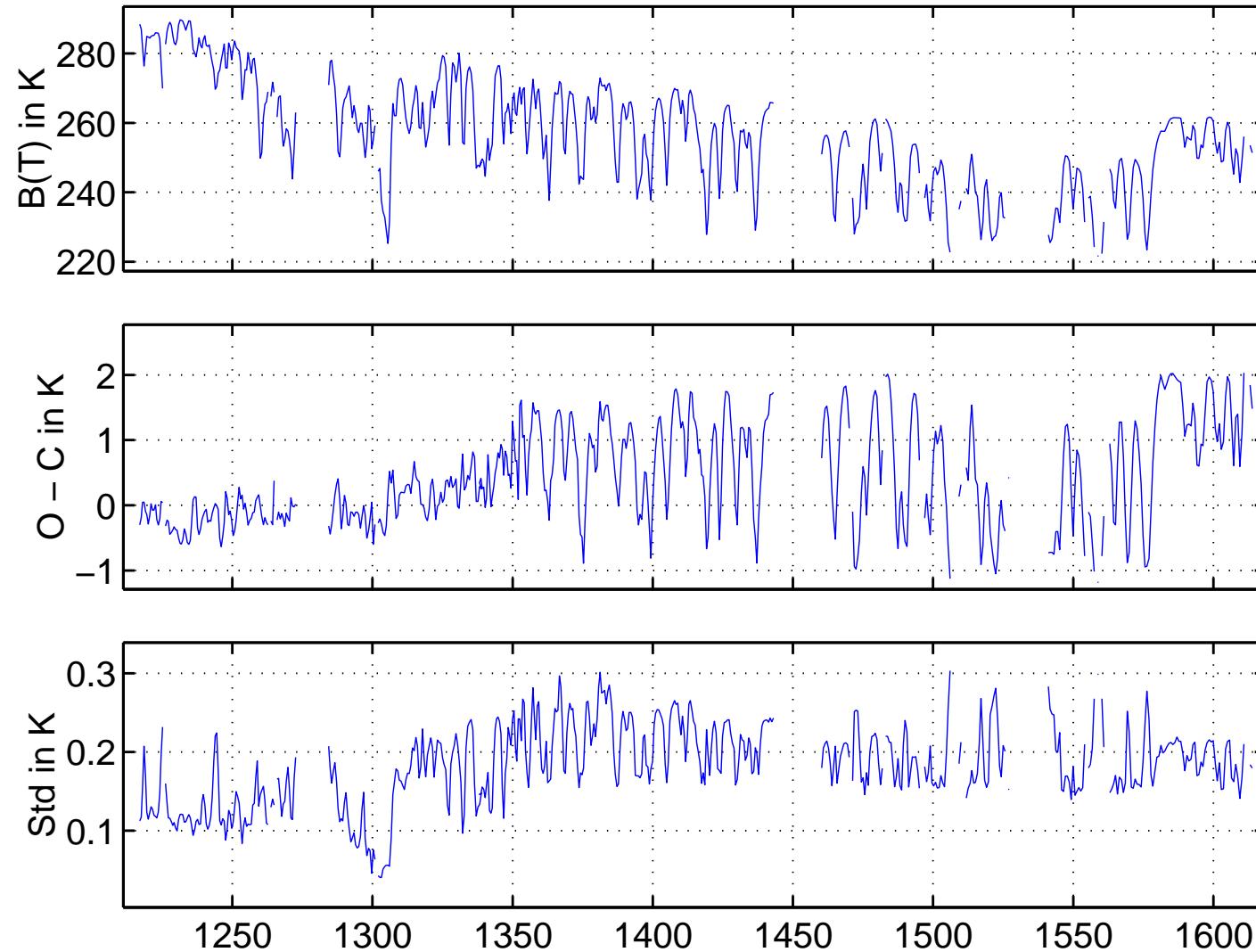
## Mean and Std of Daily Global Bias over 7 days in Sept.



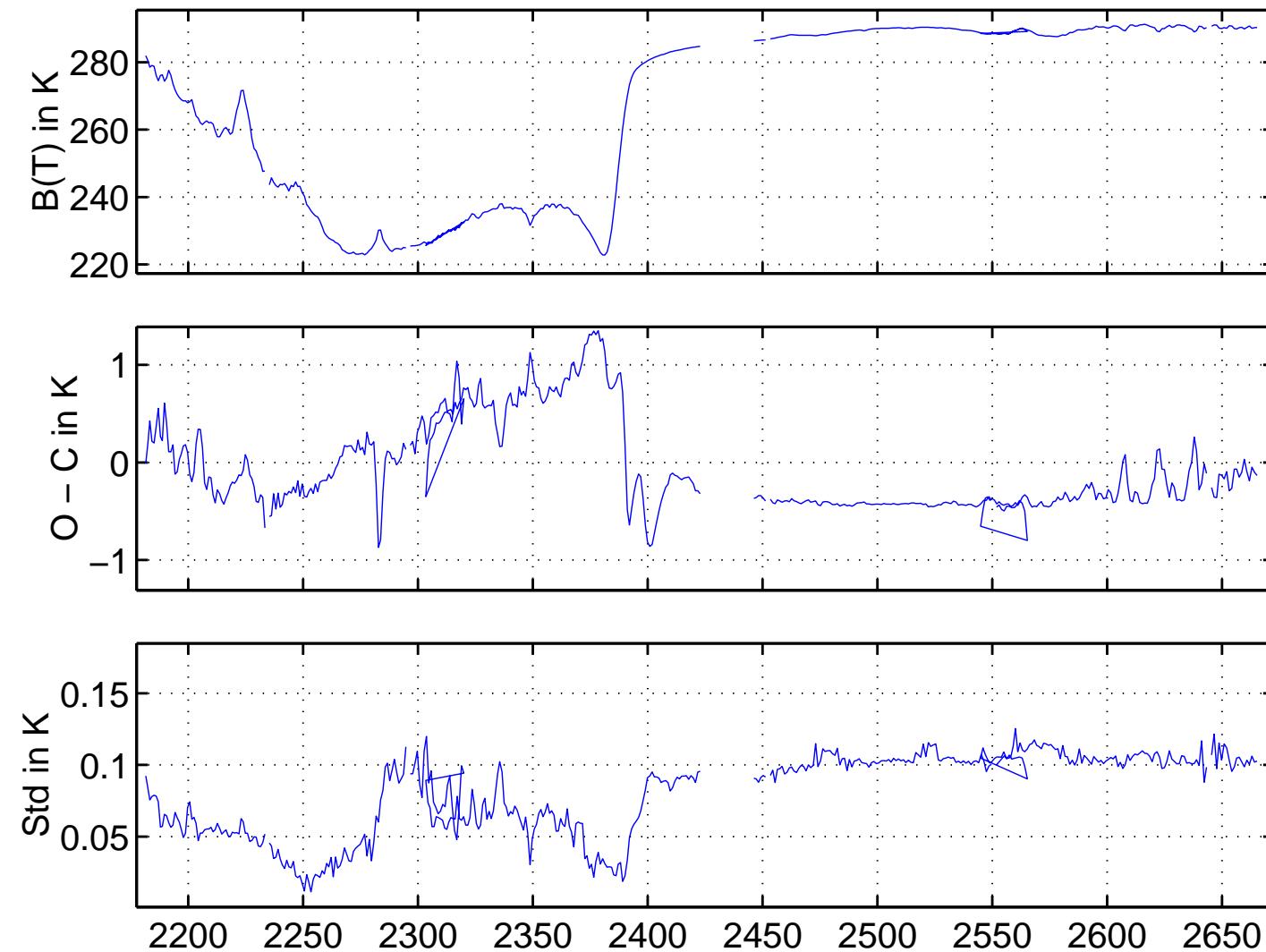
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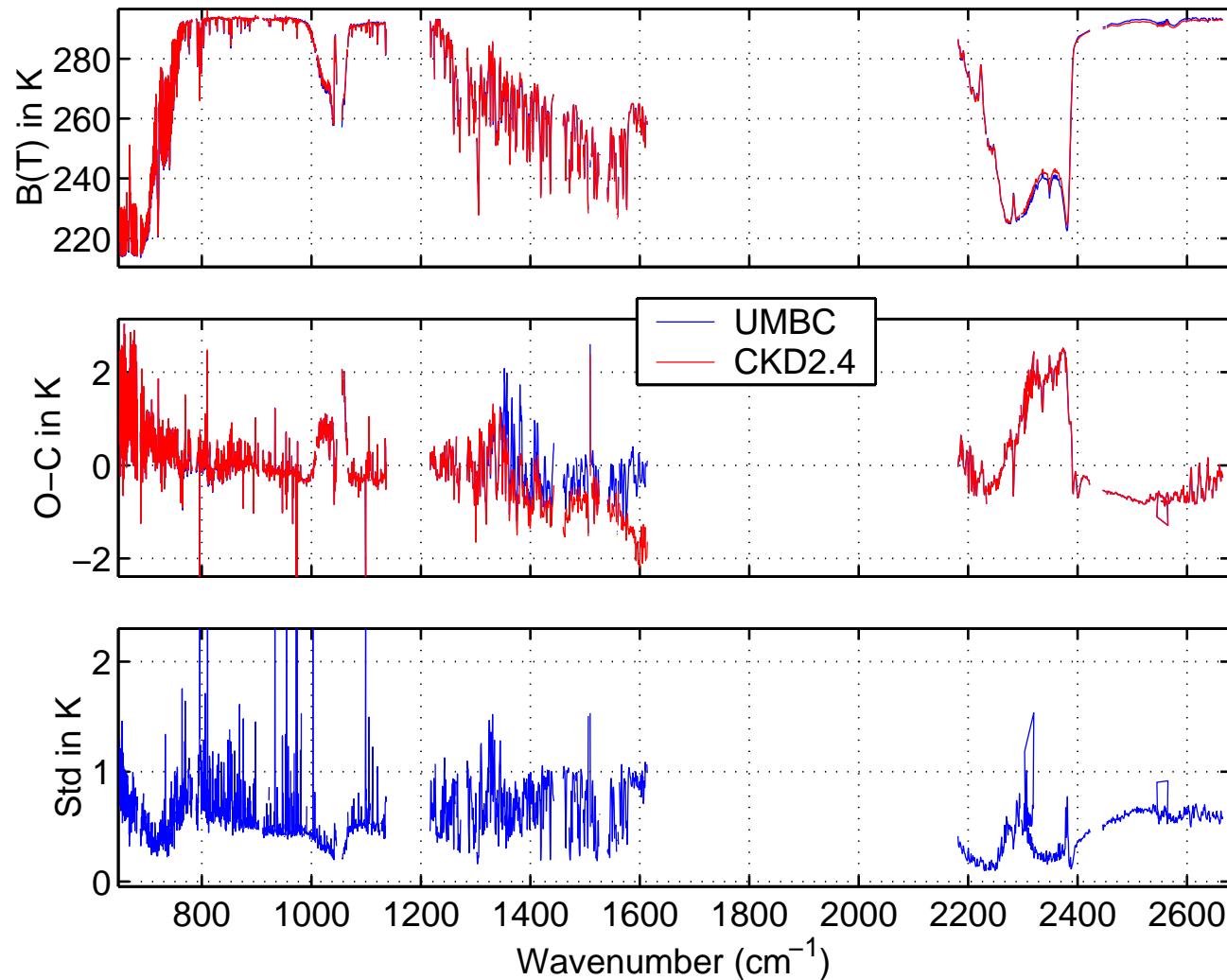
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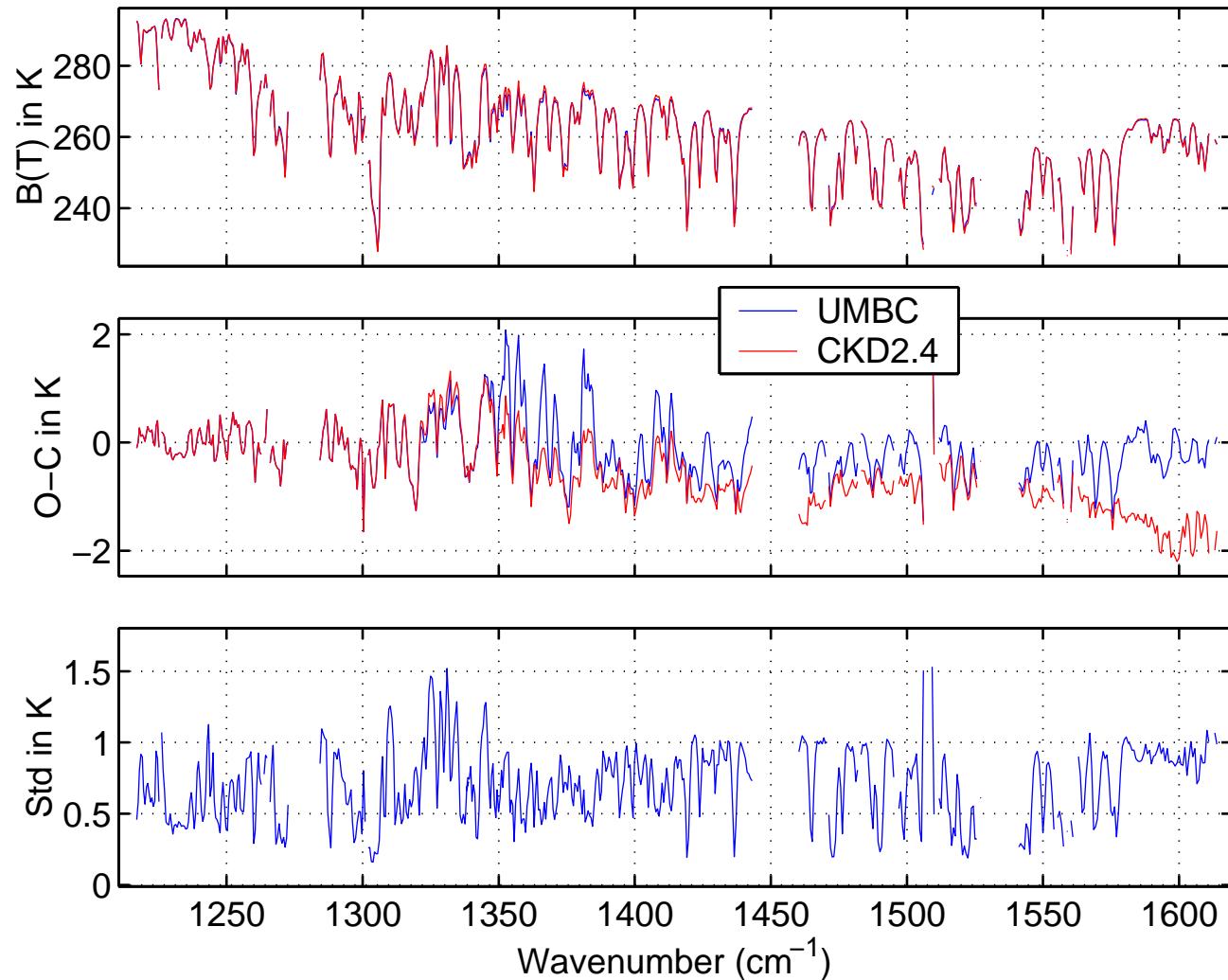
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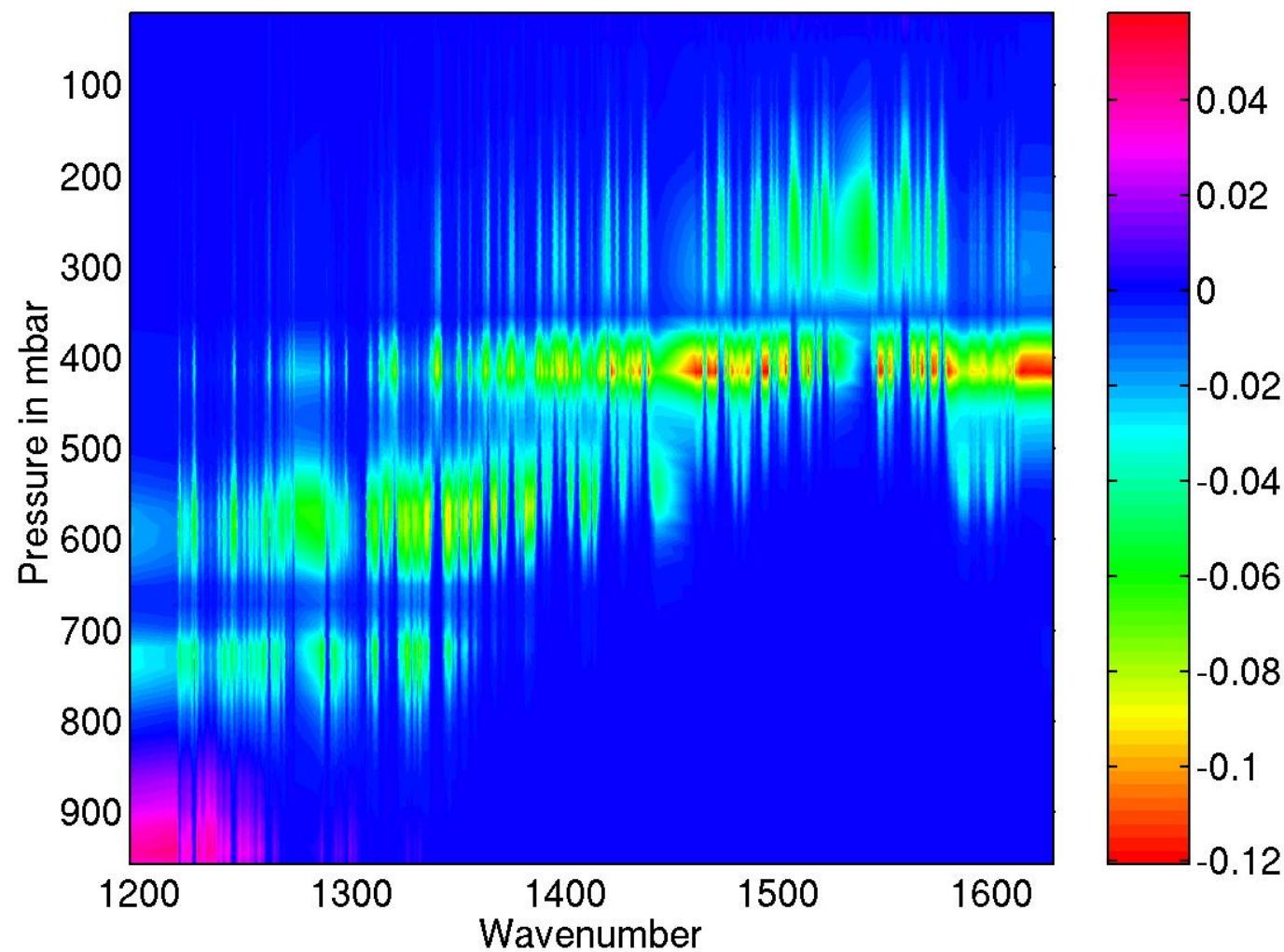
## ARM-CART July 25 Overpass

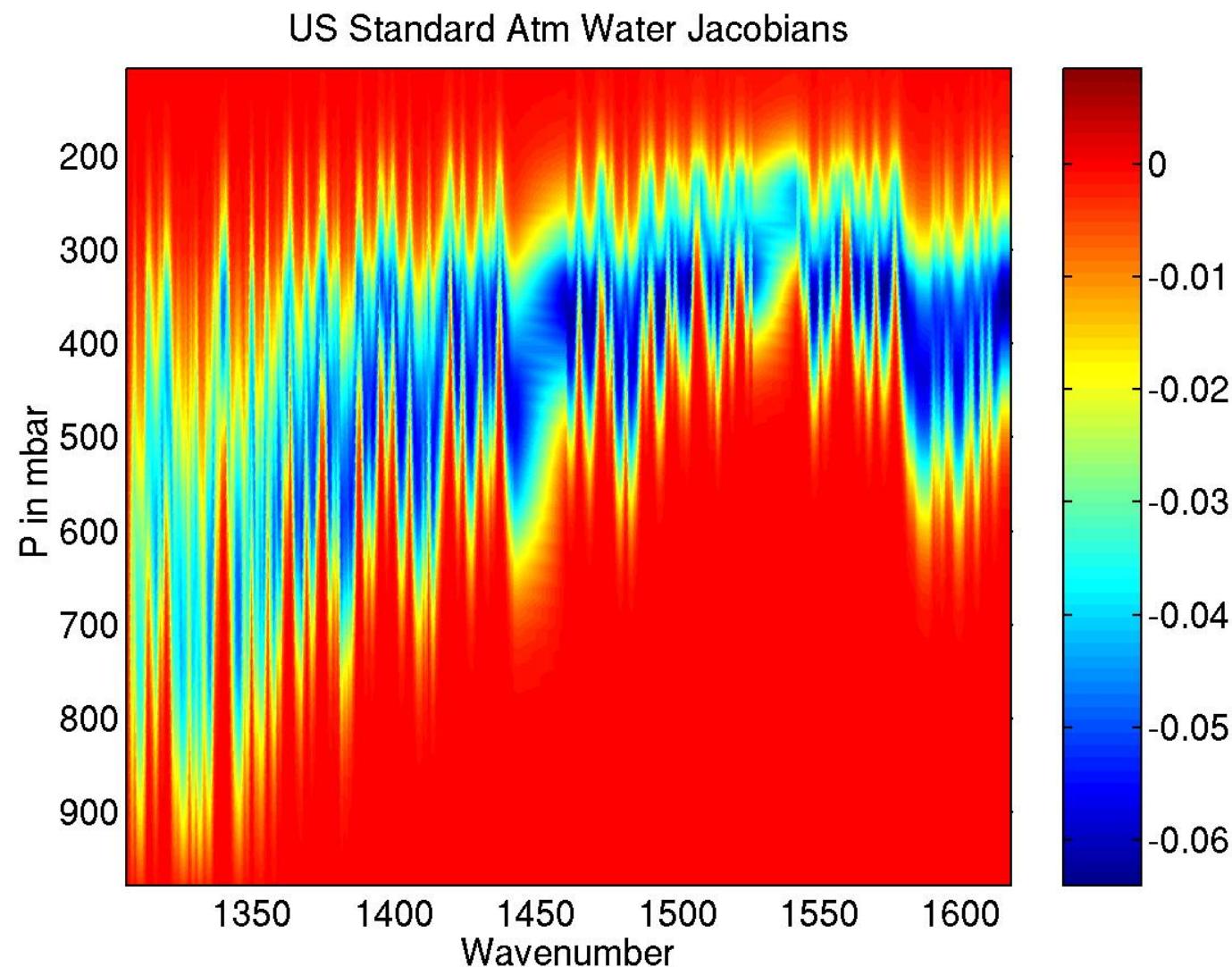


## ARM-CART July 25 Overpass, Zoom

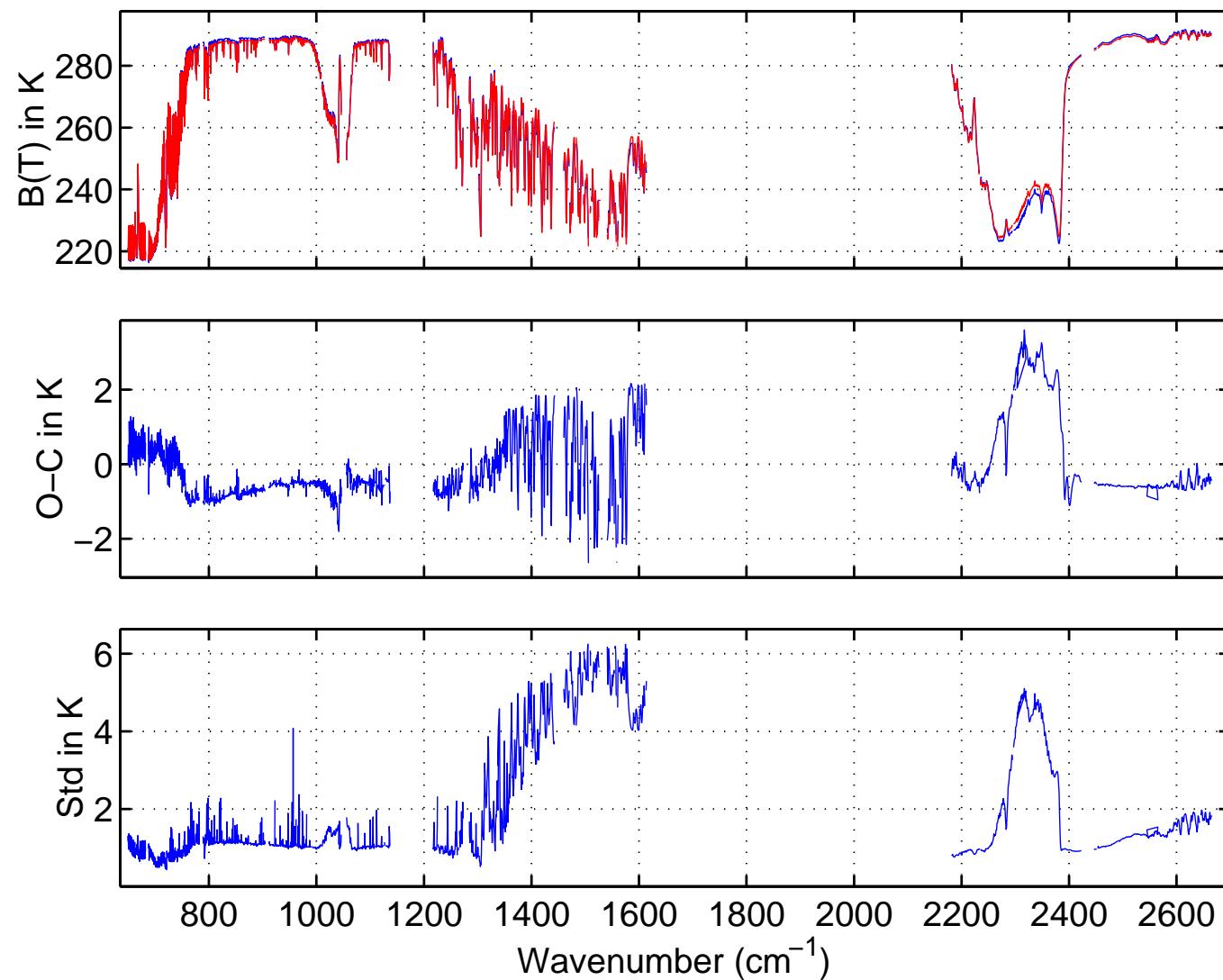


ARM-Cart Water Jacobian, July 25

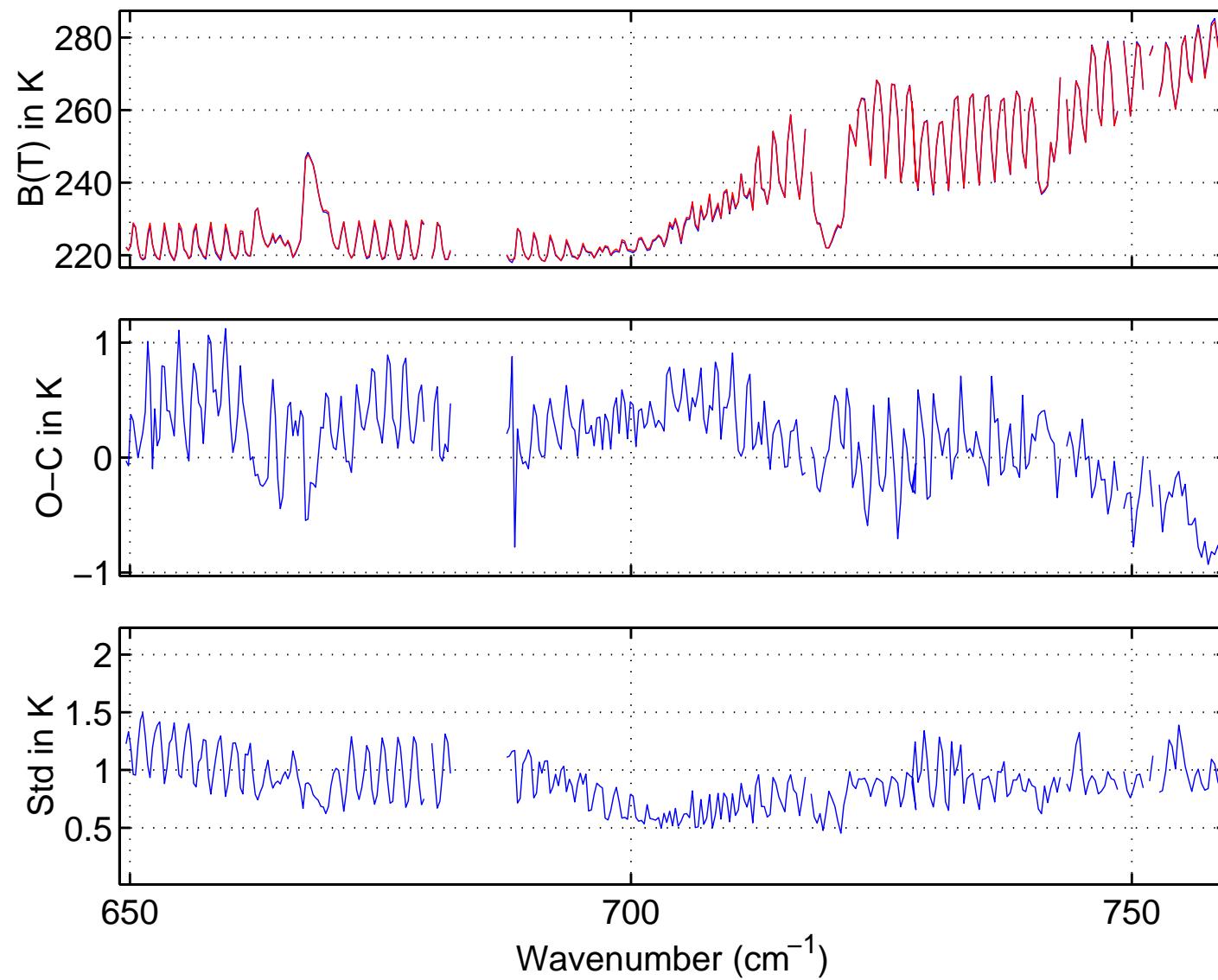




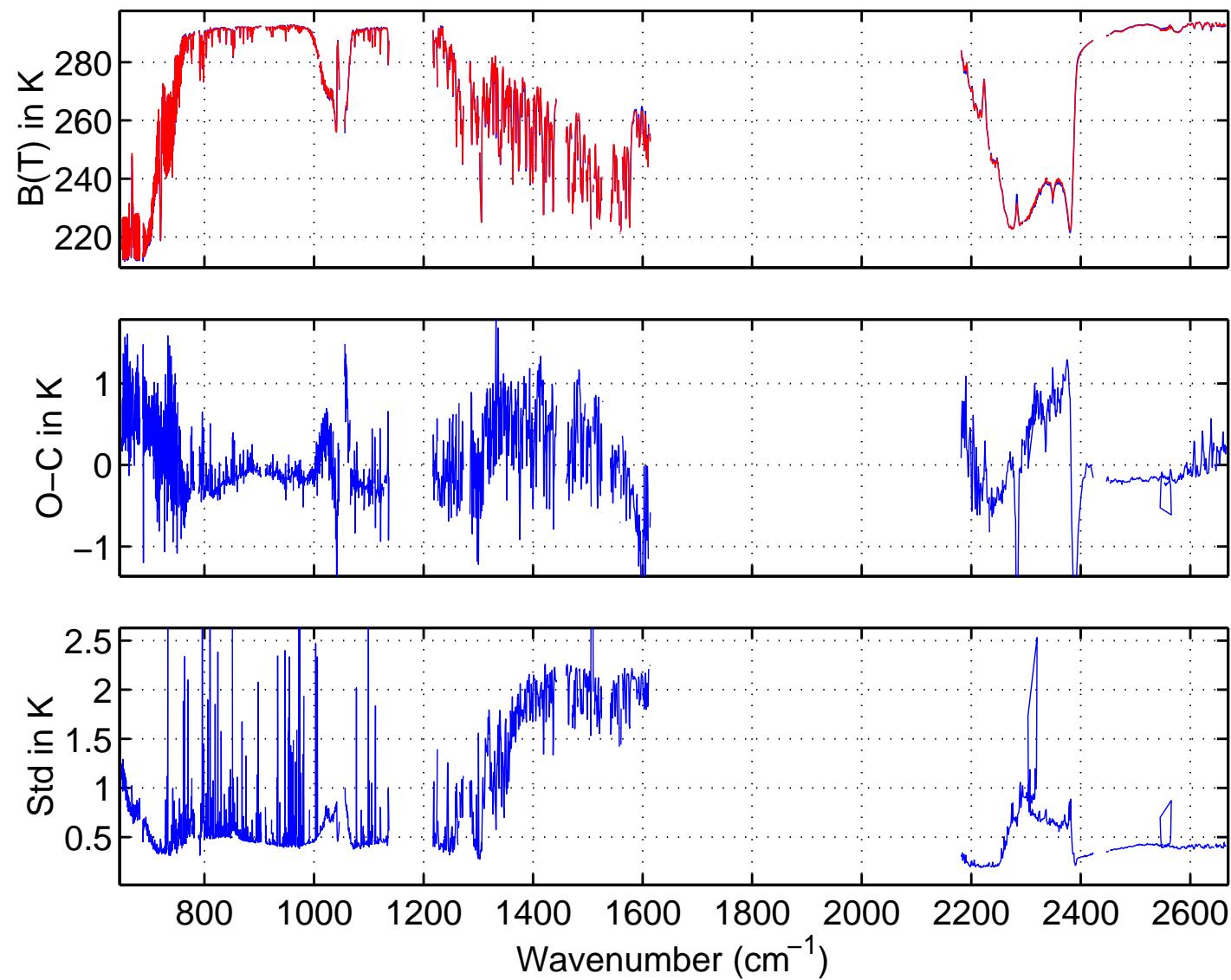
## PREPQC Sondes, Sept 1–11, Bias and Std



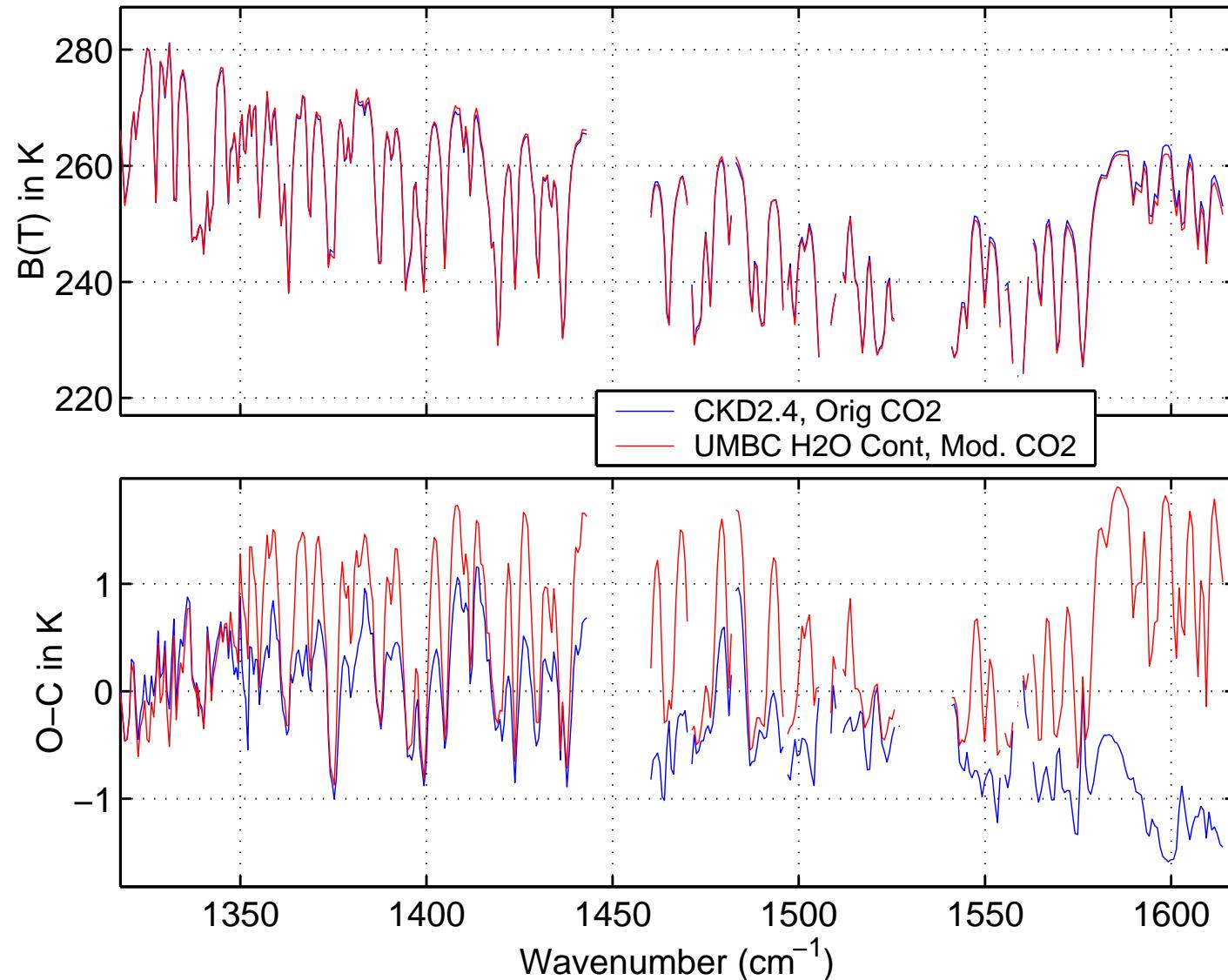
## Sonde Stats: Sept. 1–11



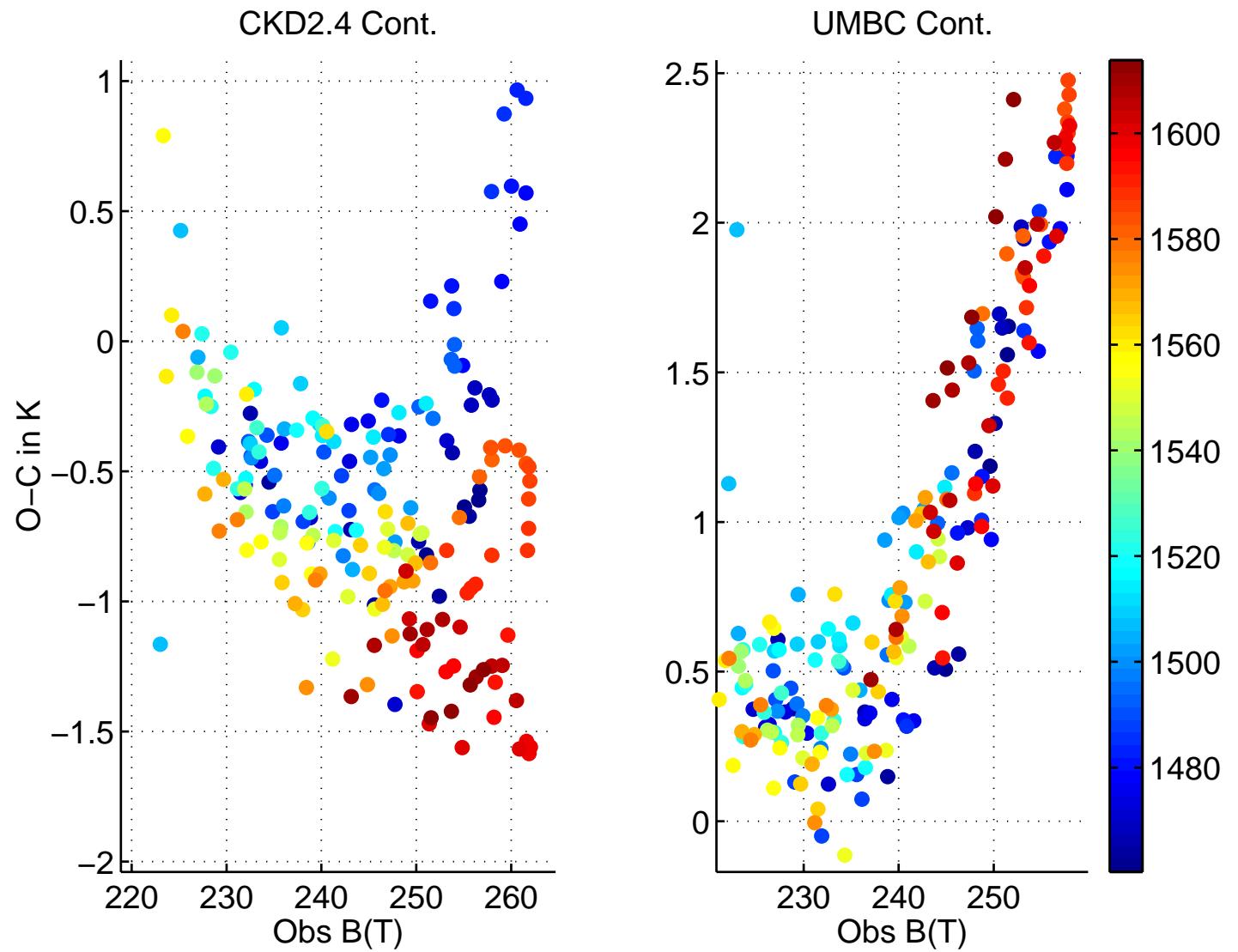
July 20 Global Bias/Std with Pre-Launch RTA



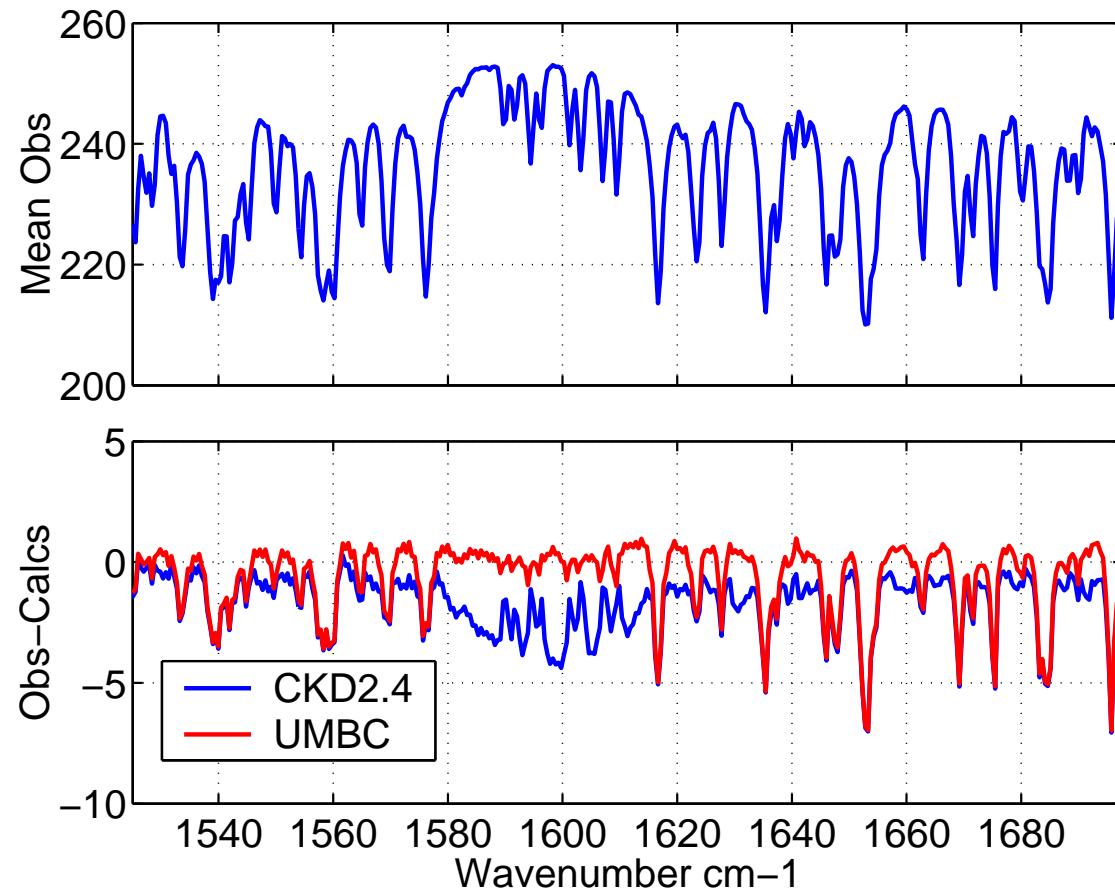
## AIRS Bias with ECMWF, CO<sub>2</sub> Corrected Using Laboratory Data



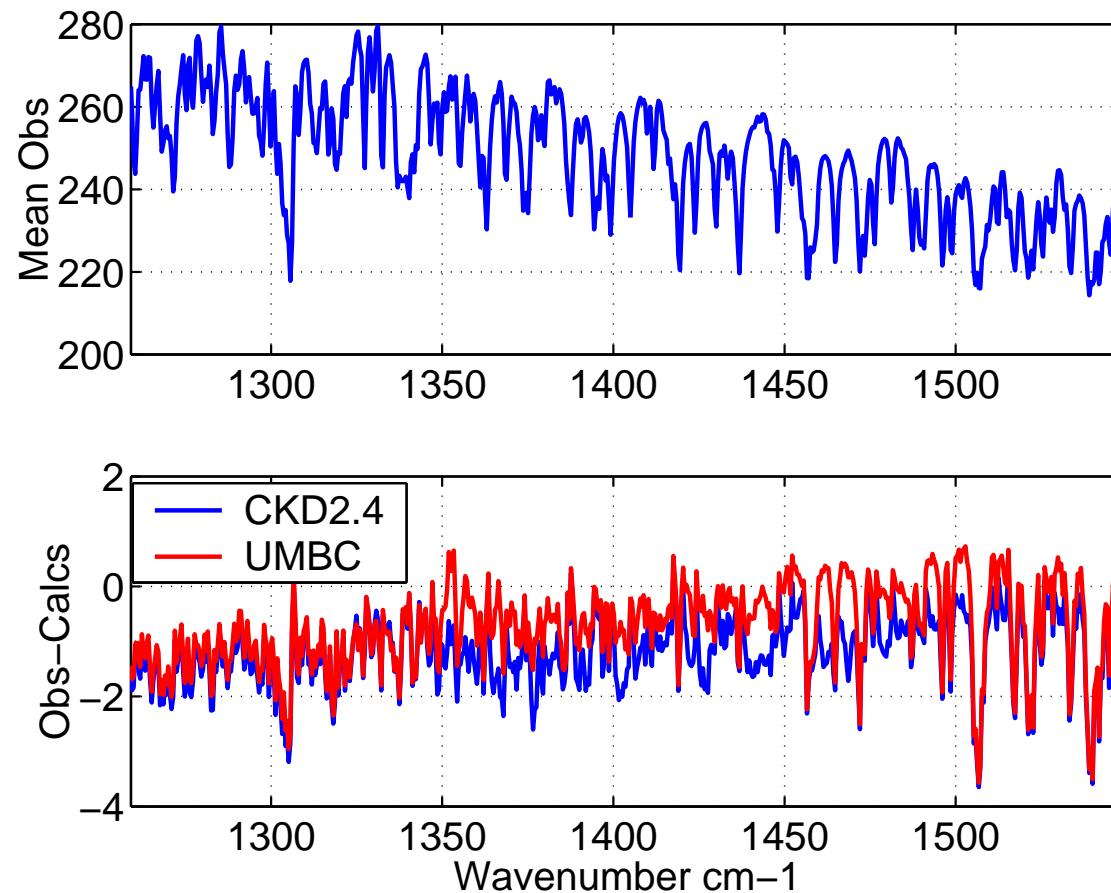
## Internal Consistency vs Accuracy, Water Vapor Continuum



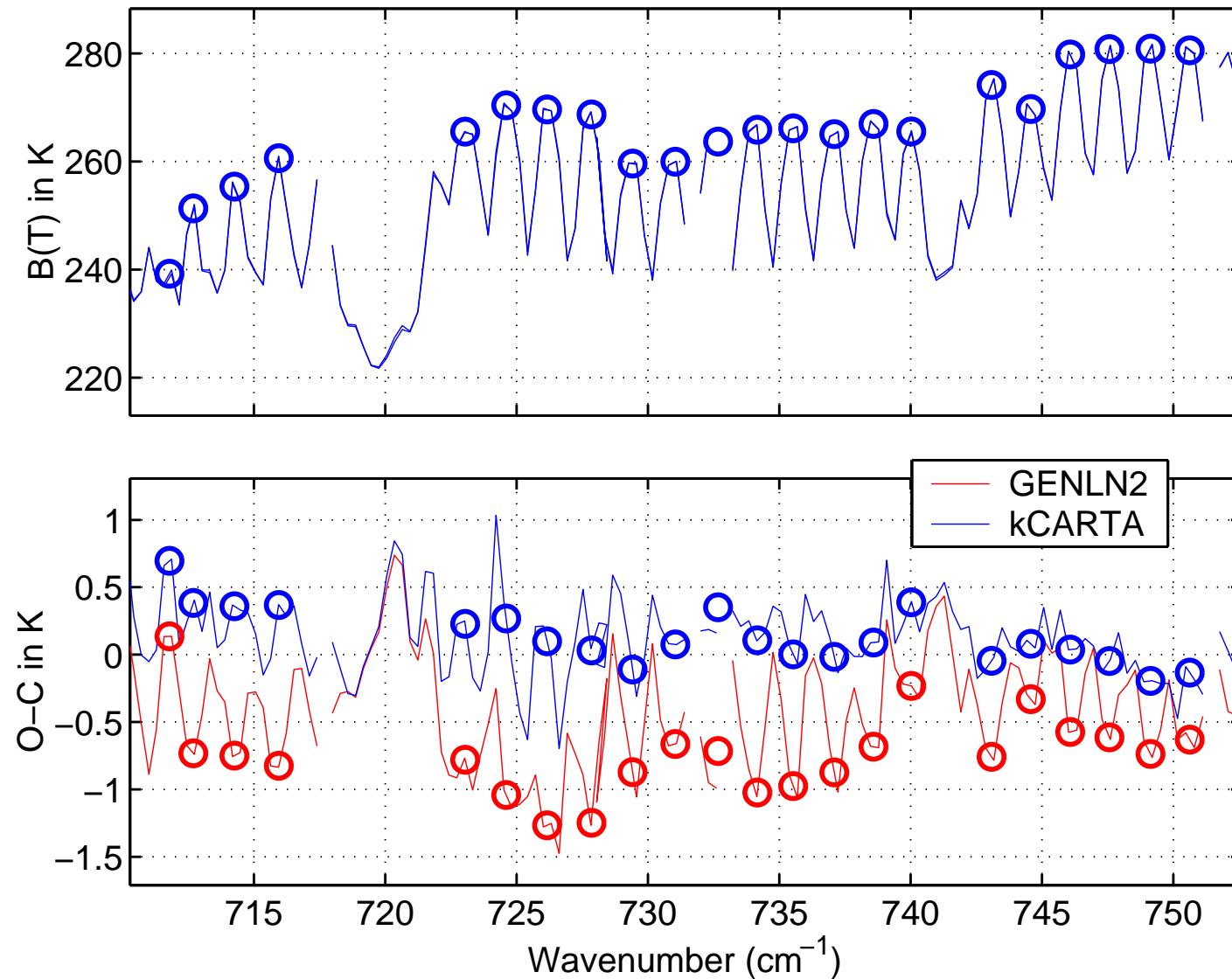
## ECMWF SHIS in the $1600\text{ cm}^{-1}$ region



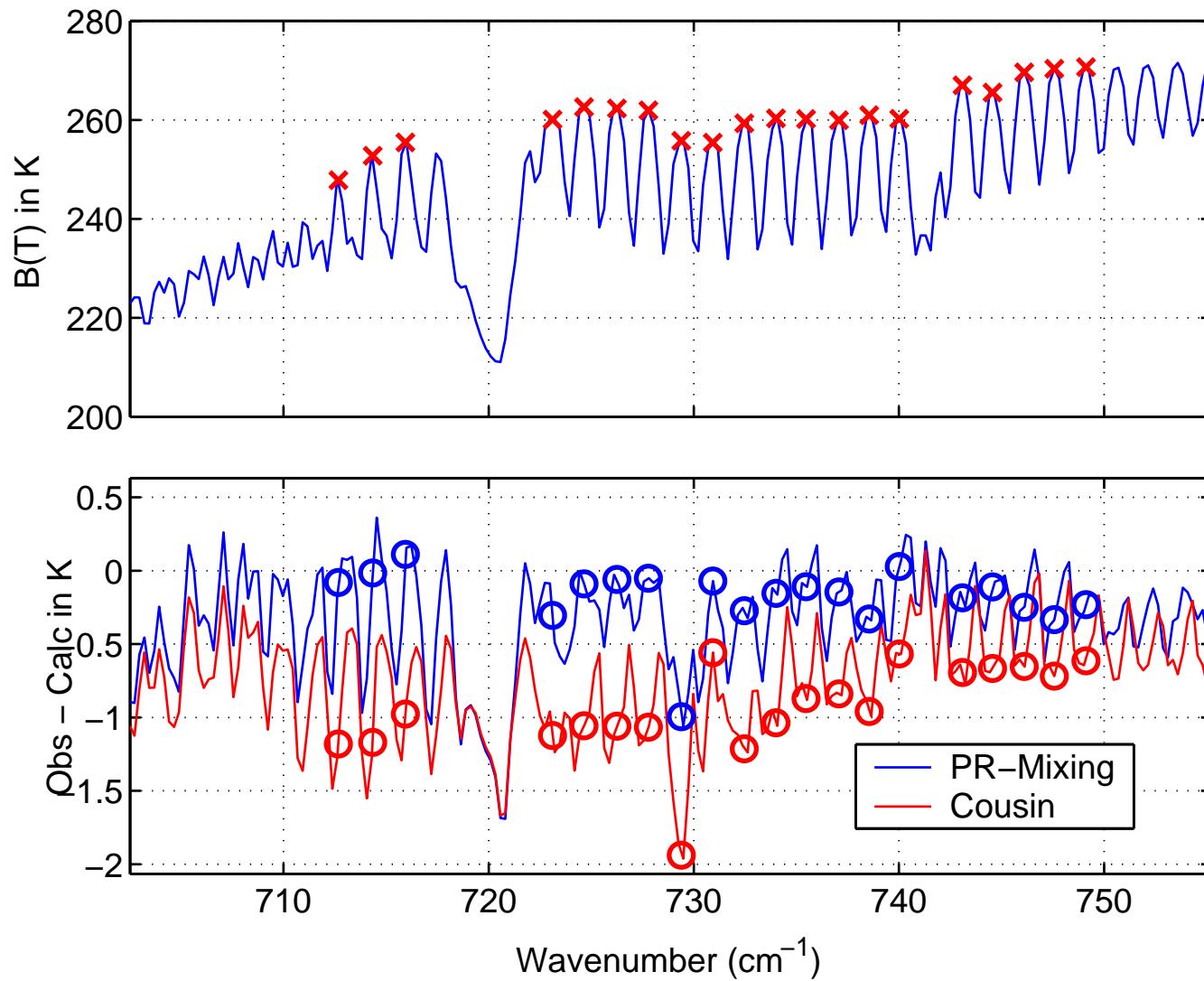
## ECMWF SHIS in the $1400\text{ cm}^{-1}$ region



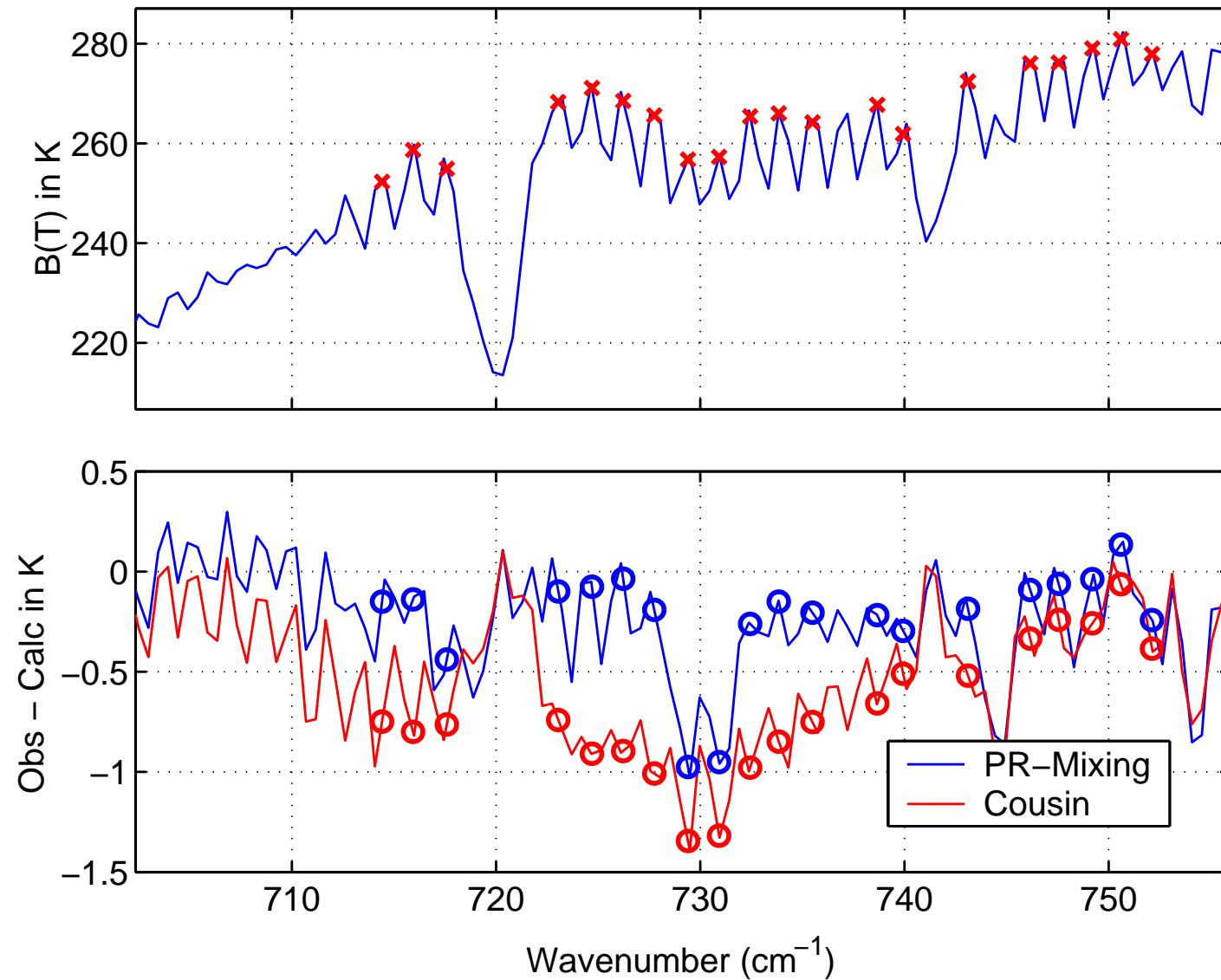
## AIRS: kCARTA versus GENLN2 AIRS Bias with ECMWF

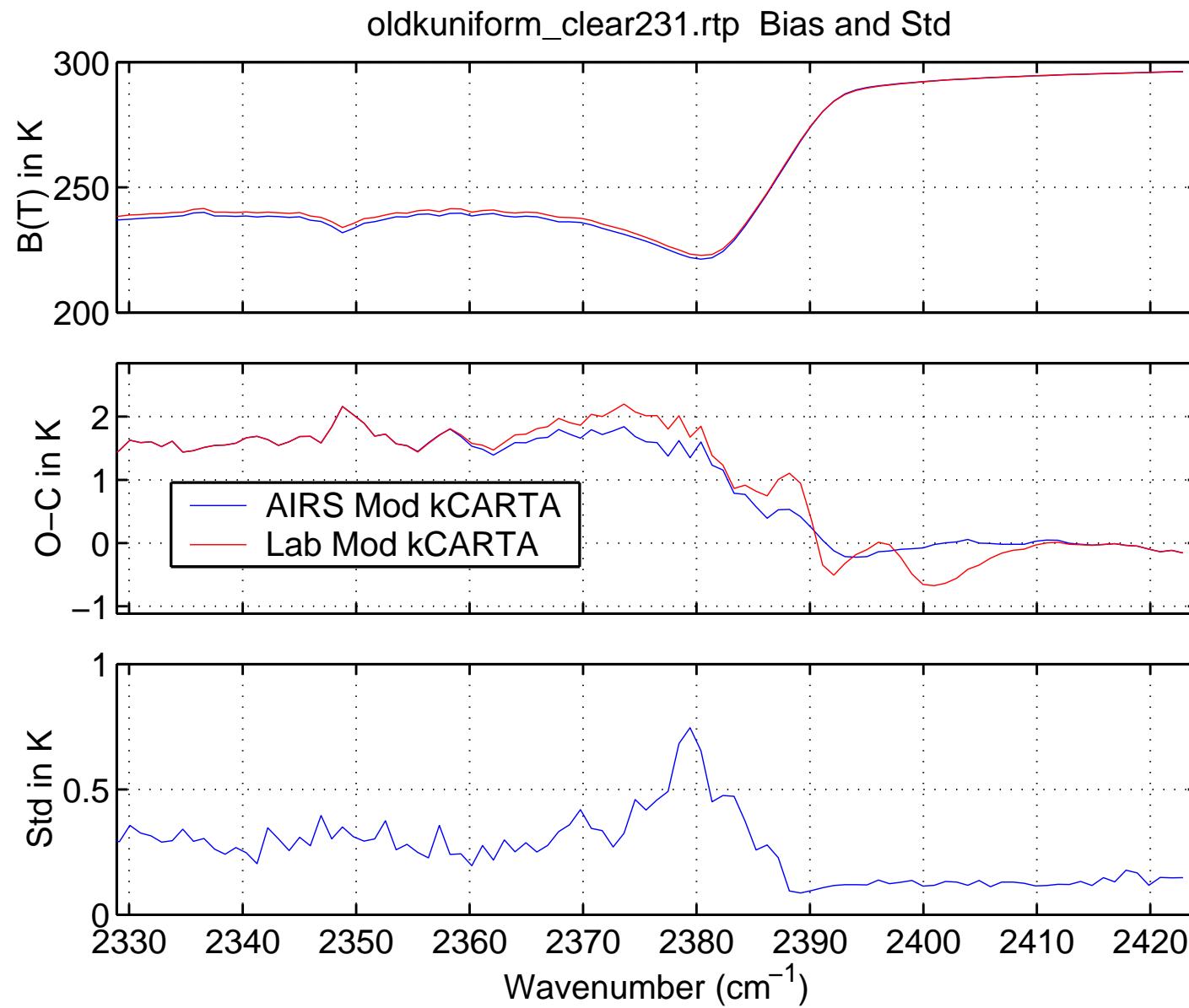


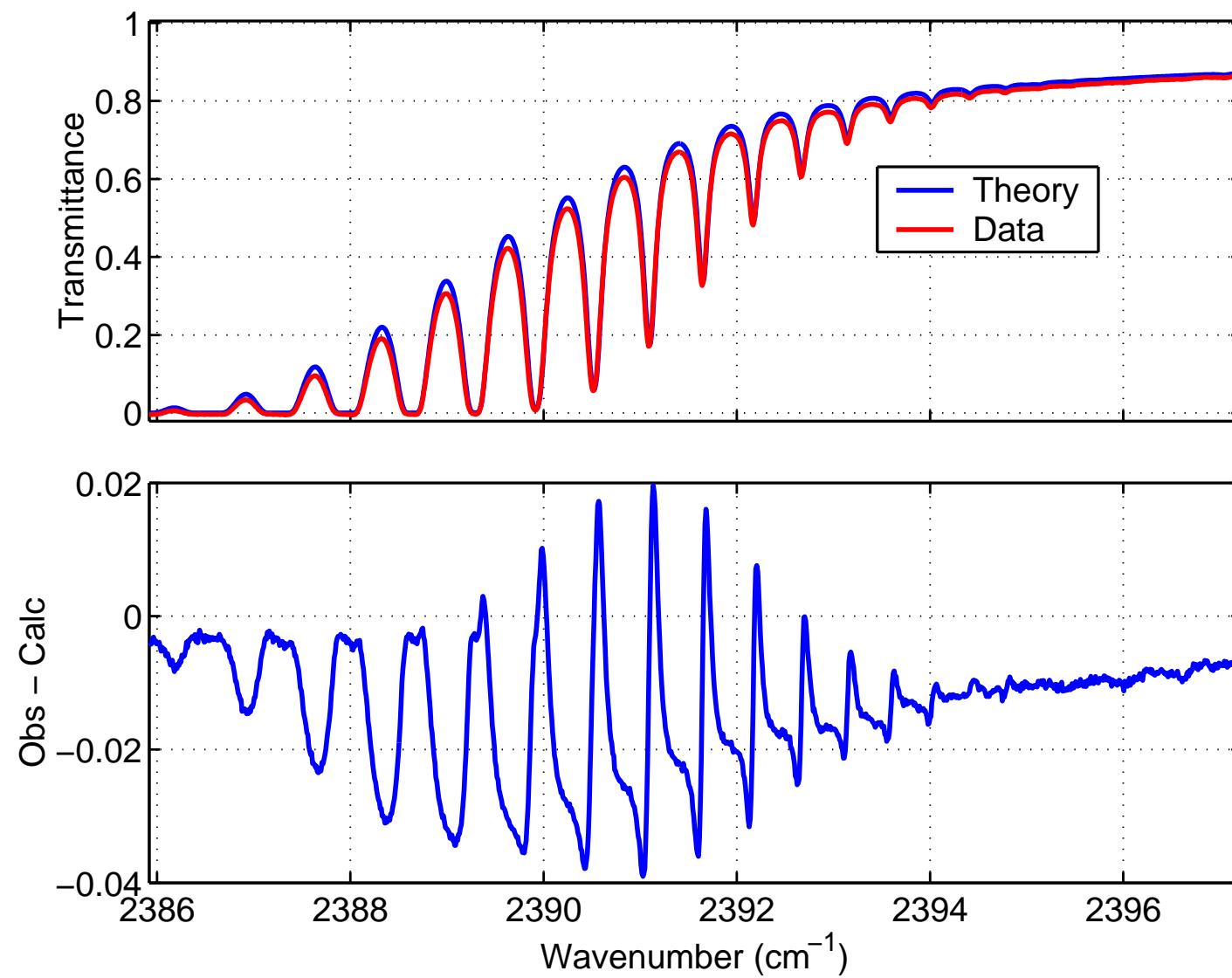
## WINTEX: O-C With and Without P/R Mixing



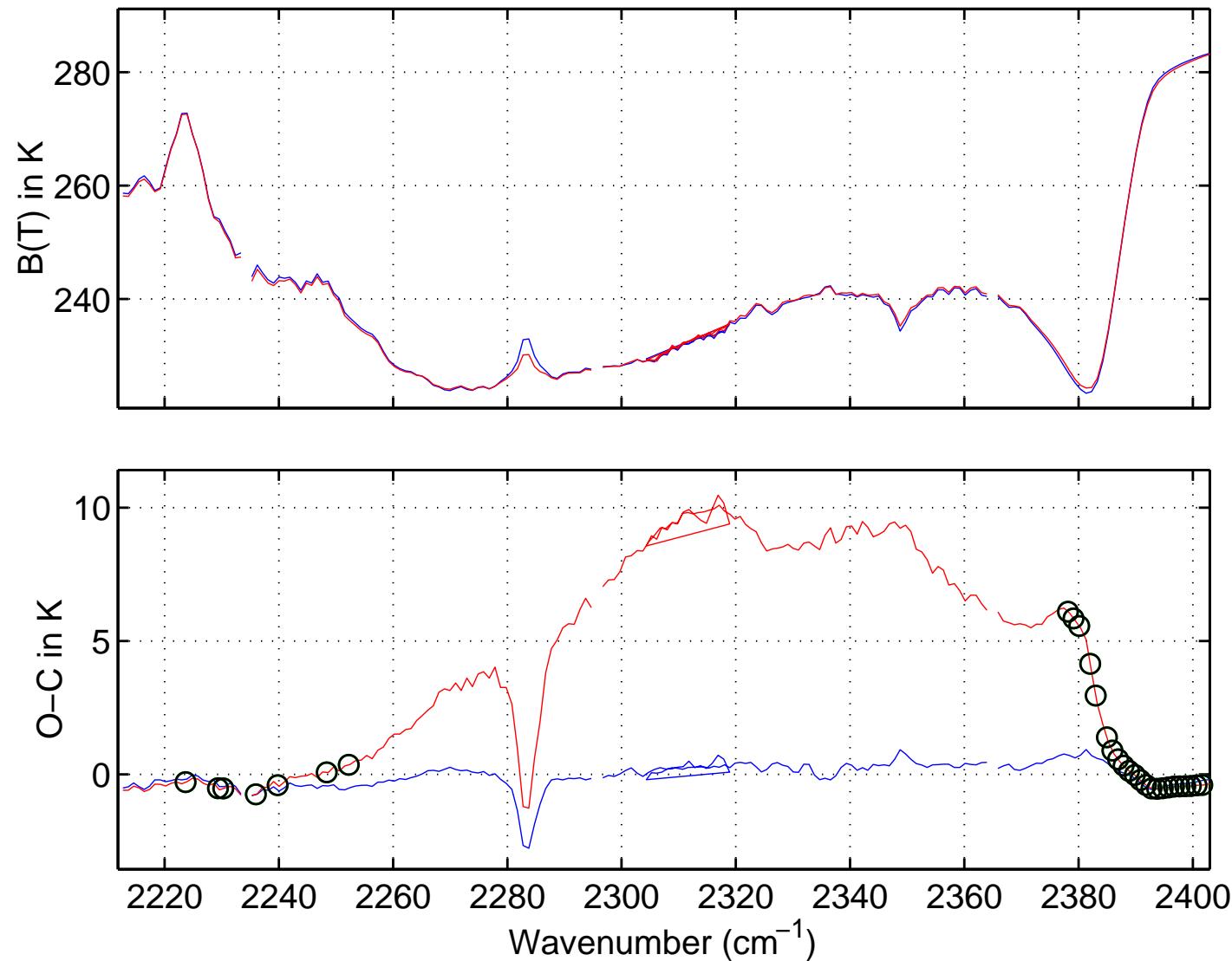
## ECMWF vs S-HIS during CLAMS

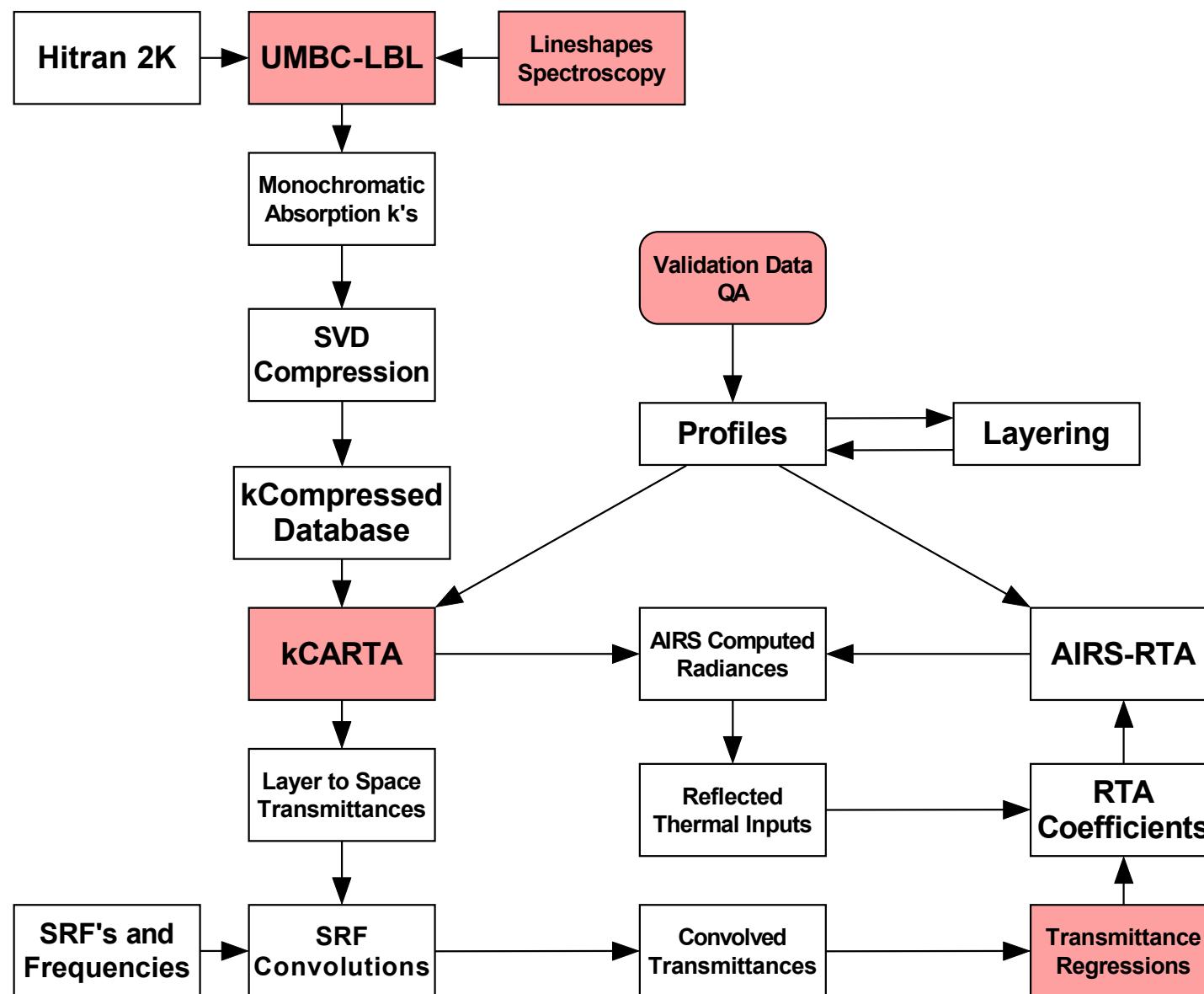




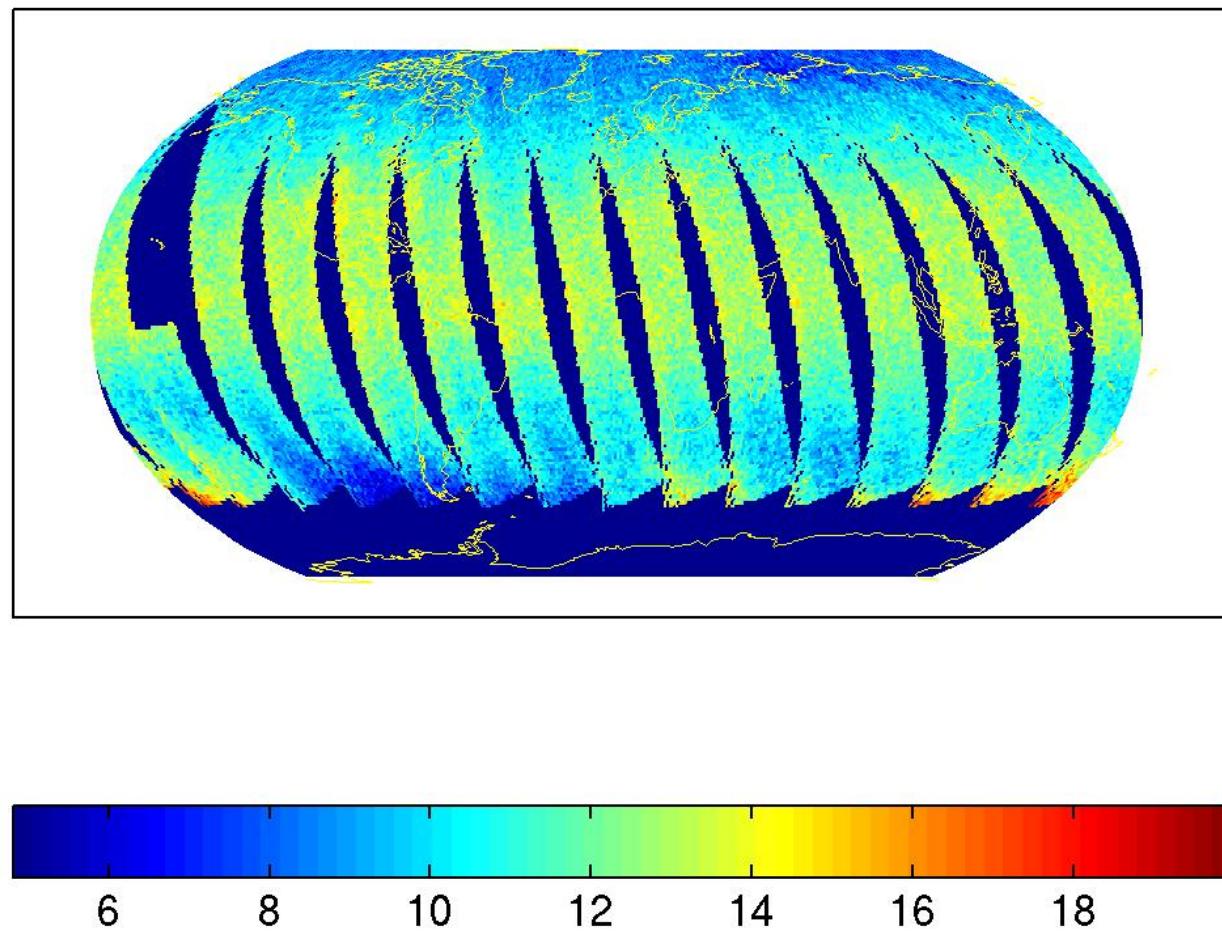


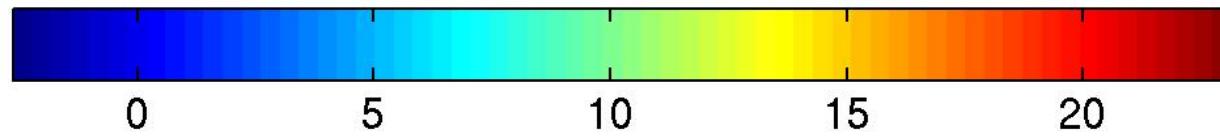
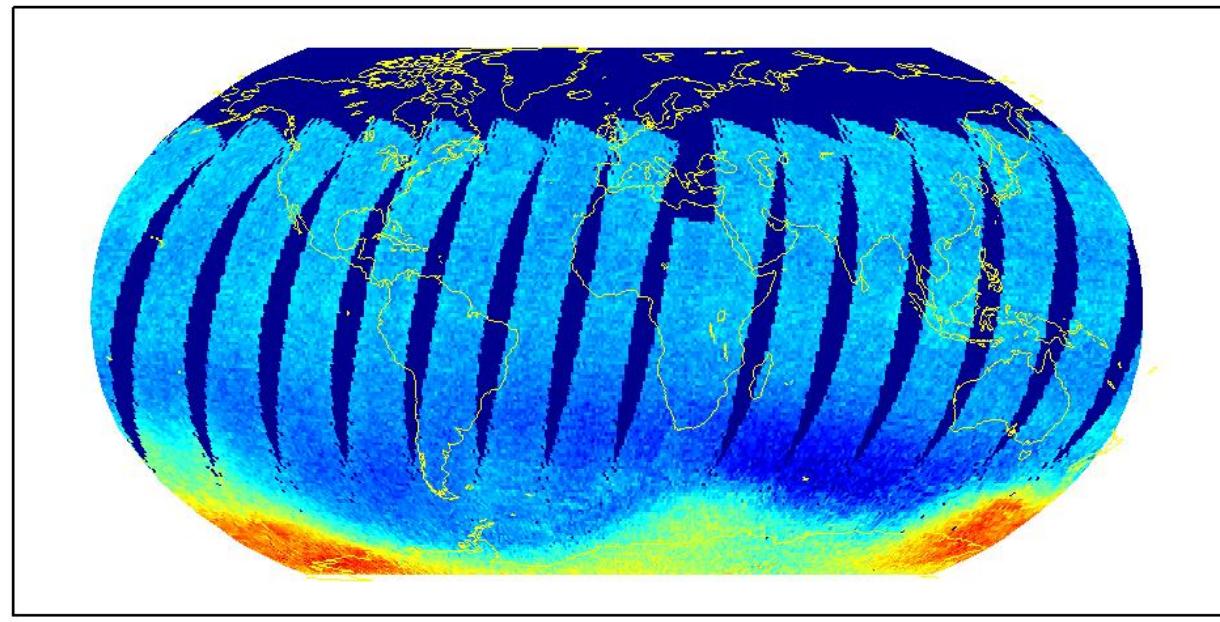
## Effect on Non-LTE on Sounding Channels

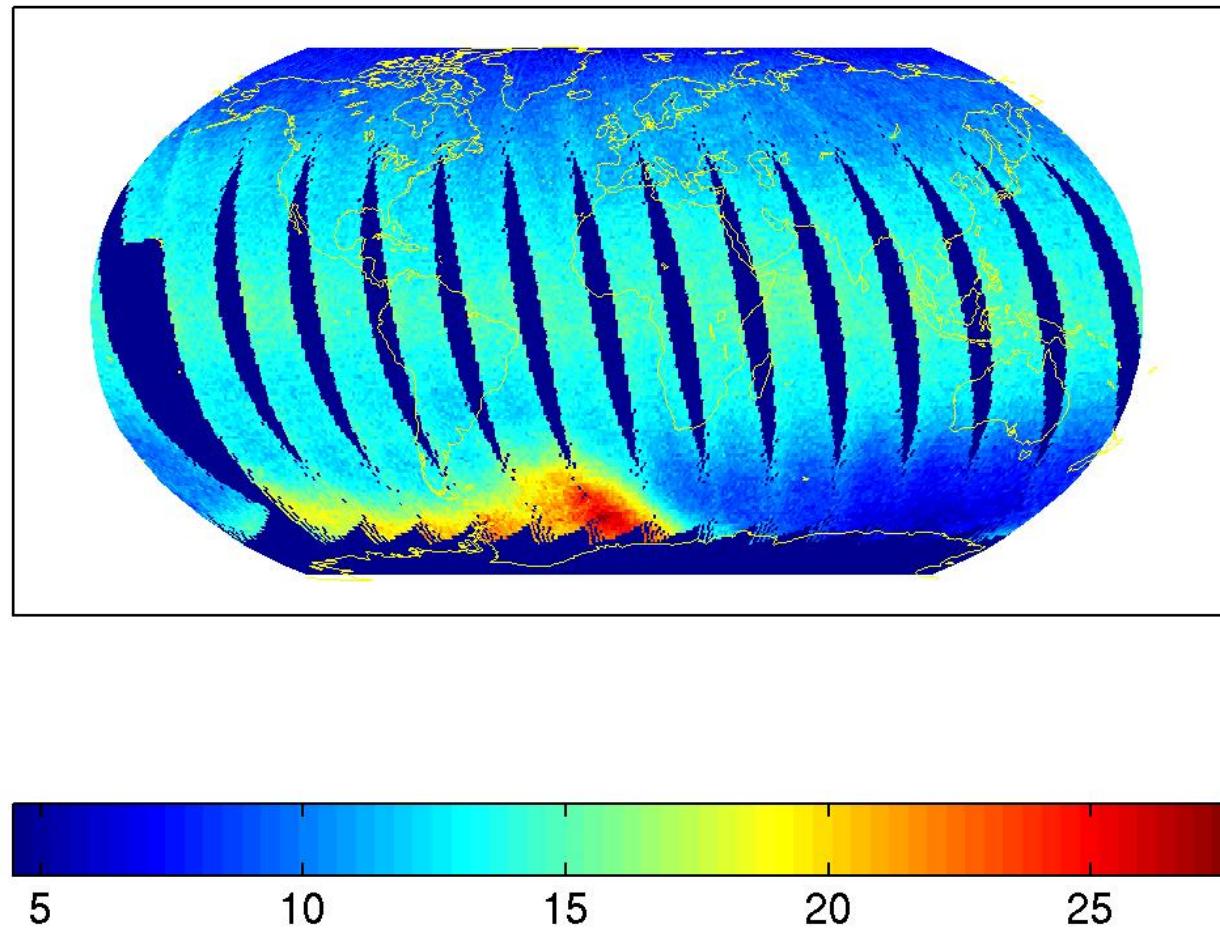


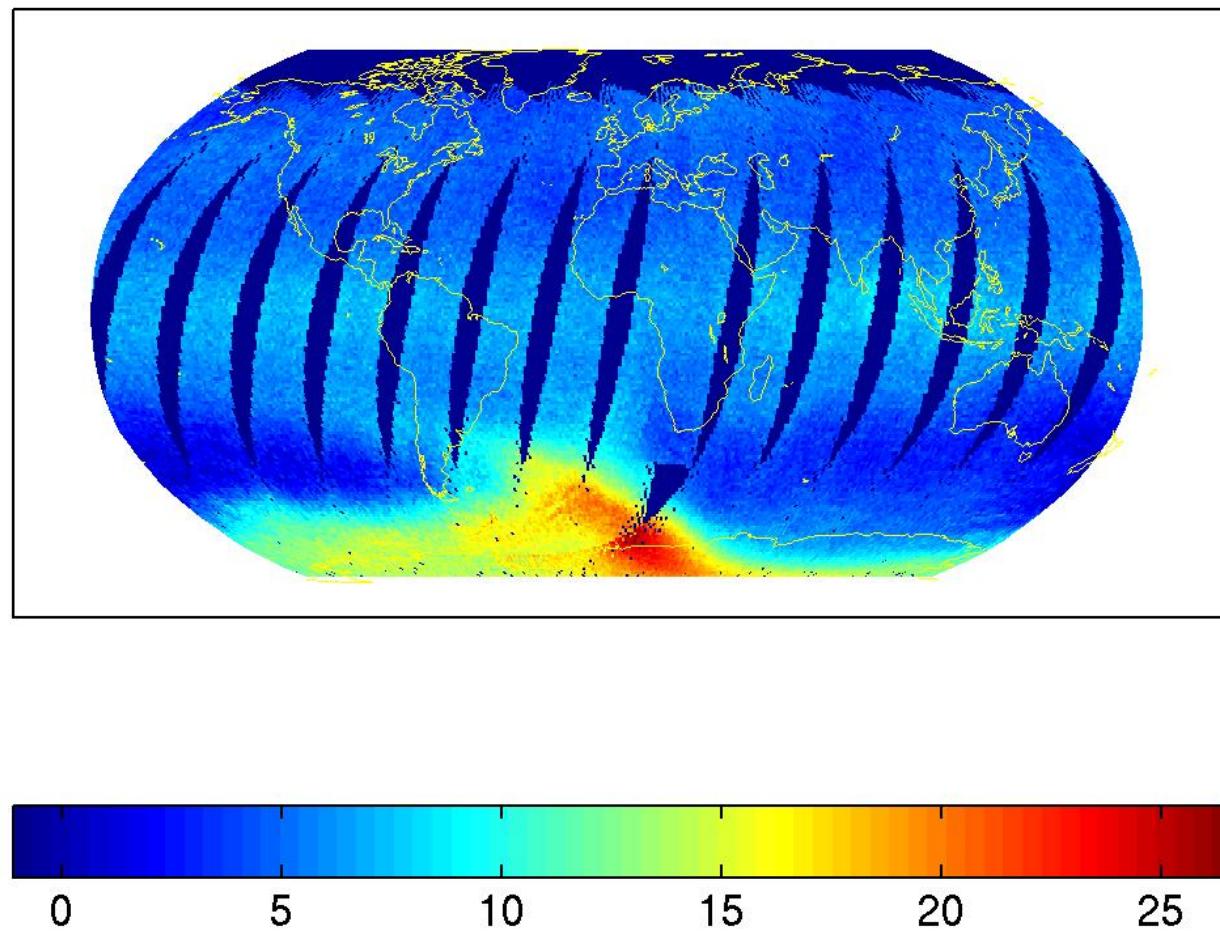


July 20, B(T) for  $(2355 - 667.5)$   $\text{cm}^{-1}$ , Daytime

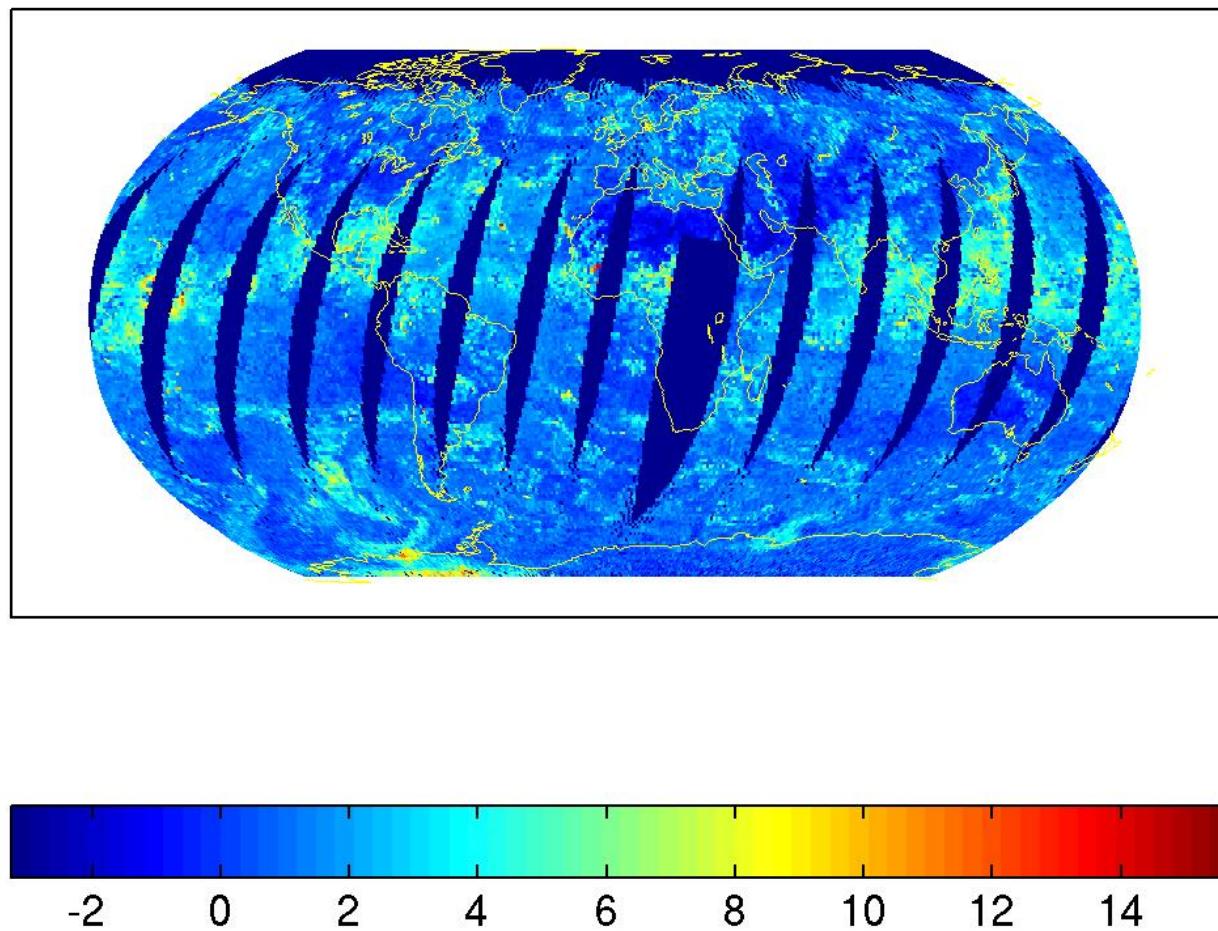


July 20, B(T) for  $(2355 - 667.5)$   $\text{cm}^{-1}$ , Nighttime

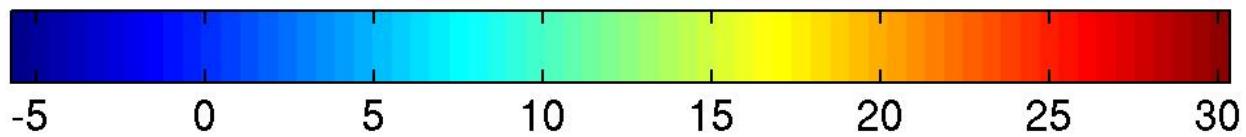
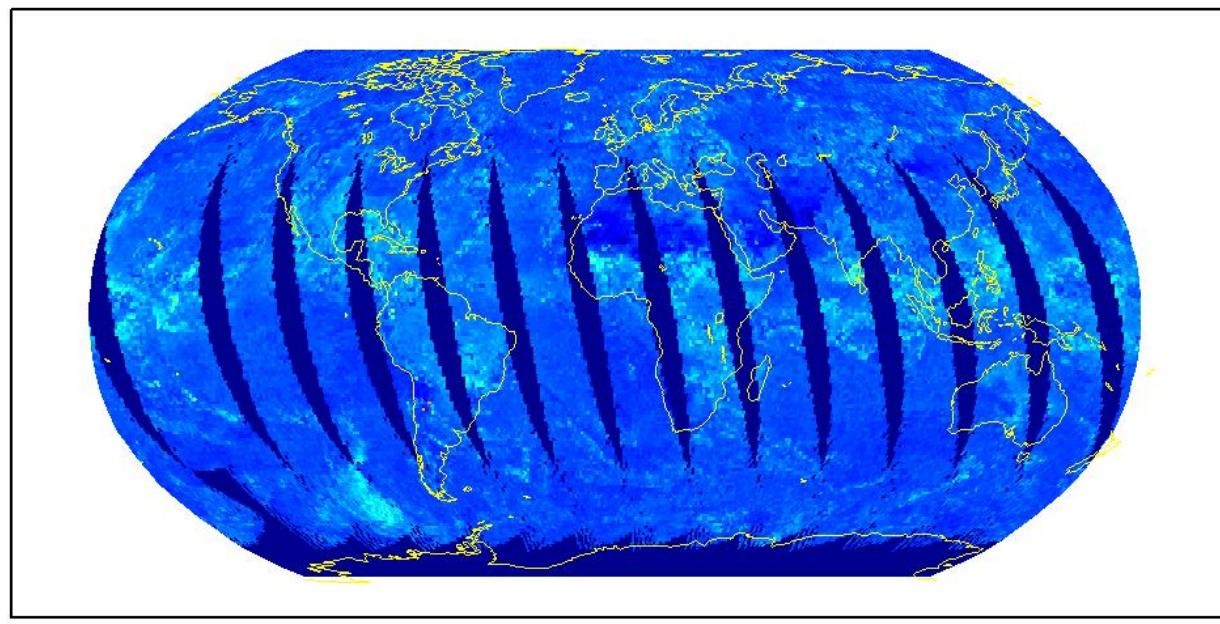
Aug 31, B(T) for  $(2355 - 667.5)$   $\text{cm}^{-1}$ , Daytime

Aug 31, B(T) for  $(2355 - 667.5)$   $\text{cm}^{-1}$ , Nighttime

Nighttime Cirrus?



Daytime Cirrus?



## Conclusions

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- Radiometric accuracy looks very good, even for low radiances
- Mid-altitude temperature channels agree to within 0.25-05K with ECMWF
- Higher altitude channels at 15 microns suggest ECMWF is biased cold
- 4 micron CO<sub>2</sub> temperature channels are inconsistent with 15 micron channels by ~ 1K. We suspect the spectroscopy, with some SRF errors mixed in. More work needed.
- Validation of the AIRS-RTA for water channels will be difficult. We need all the validation data we can get with good sondes (RS-90's) and lidar. ECMWF and PREPQC seem to give the same biases. Aircraft and laboratory data suggests both are wrong. Higher altitude water biased low in sondes/ECMWF, as expected.
- non-LTE will limit use of some higher-altitude channels at 4.3 microns. Model calculations qualitatively agree with observations (away from South Polar regions).

- We need to emphasize the many new products AIRS can produce in order to generate excitement at NASA HQ and in the scientific community, e.g. CO, CO<sub>2</sub>, CH<sub>4</sub>, cirrus properties, land surface properties, etc.
- But first, we need to show that cloud-cleared radiances do not significantly change NCEP/ECMWF bias and standard deviations.
- We can “tune” the AIRS-RTA via transmittance adjustments. Should be more physical (more accurate) than tuning radiances.
- Determining the truth will take time, but is important for the climate record.